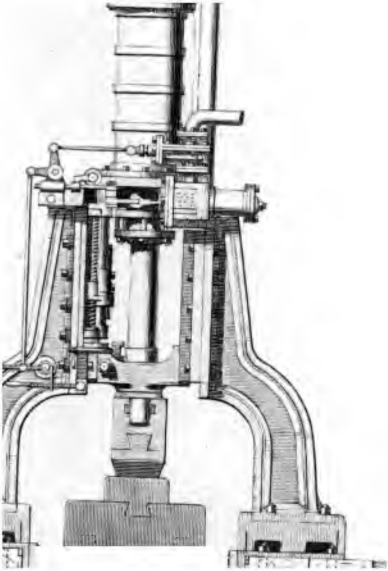

THE

OPERATIVE MECHANIC'S WORKSHOP COMPANION,

AND

THE SCIENTIFIC GENTLEMAN'S

Practical Assistant;

COMPRISING

A GREAT VARIETY OF THE MOST USEFUL RULES IN MECHANICAL SCIENCE,

WITH

NUMEROUS TABLES OF PRACTICAL DATA AND CALCULATED RESULTS FOR FACILITATING MECHANICAL AND COMMERCIAL TRANSACTIONS.

BY WILLIAM TEMPLETON.

EIGHTH EDITION, REVISED AND ENLARGED,

WITH THE ADDITION OF

MECHANICAL TABLES FOR THE USE OF OPERATIVE SMITHS, MILLWRIGHTS, ENGINEERS, ETC.

TO WHICH ALSO HAVE BEEN NOW ADDED

SEVERAL USEFUL AND PRACTICAL RULES IN

HYDRAULICS AND HYDRODYNAMICS,

A VARIETY OF EXPERIMENTAL RESULTS,

AND

AN EXTENSIVE TABLE OF POWERS AND ROOTS.

LONDON:
LOCKWOOD & CO., 7, STATIONERS' HALL COURT.
1864.

HARRILD, PRINTER, LONDON.

TO THE PUBLIC.

THE subjects of the following pages are chiefly compiled at the instigation of pressing solicitations by numerous individuals, no few of whom complain of the want of a convenient Text Book of Reference in which Mechanical and Commercial demands are judiciously combined. Others, with apparently equal reasons, for the sake of instruction, complain of the want of a compendium in which tuition and practical reference are discriminately arranged; and generally, that for purposes of Estimation, no properly portable work is yet in existence; hence it is with a wish to diminish those wants in some degree that the present attempt has been made to supply the necessary information.

In regard to the selection, great care has been taken that the subjects be not only intimately interwoven, but also of such a nature as business transactions call most frequently into requisition.

The elementary or educational portion will be found exceedingly plain and simple, though compendious. The practical rules, too, are much abbreviated by the application of decimal approximates, by which results are obtained sufficiently

ɜngravings are interspersed, which
ı value in regard to practical utility;
ains to add the hope, that the Opera
Science, and the intelligent Public,
ıpreciation to the work, in proportio

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eceding, or seventh edition was n
y the insertion of numerous Table
f Operative Smiths, Millwrights,
and the present, which has under
ɡ revision, is, it is hoped, rendered
ɜeptable, by the introduction of a co
ɩuares and Cubes, with the correspoı
ıd also by additional information
ous kind, on matters of philosoɪ
cal utility.

1864.

CONTENTS.

INSTRUMENTAL ARITHME

COMMERCIAL TABLES.

LIST OF PLATES.

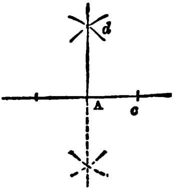
THE WORKSHOP COMPANION.

PRACTICAL GEOMETRY.

GEOMETRY is the science which investigates and demonstrates the properties of lines, surfaces, and solids: hence, PRACTICAL GEOMETRY is the method of applying the rules of the science to practical purposes.

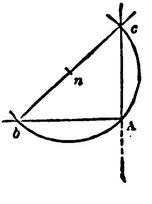
1. *From any given point, in a straight line, to erect a perpendicular; or, to make a line at right angles with a given line.*

On each side of the point A from which the line is to be drawn, take equal distances, as A *b*, A *c*; and from *b* and *c* as centres, with any distance greater than *b* A, or *c* A, describe arcs cutting each other at *d*; join A *d*, which will be the perpendicular, and it will bisect *b c*.

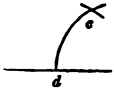


2. *When a perpendicular is to be drawn at or near the end of a given line.*

Take any point *n* above A *b*, and with centre *n* and distance *n* A, describe a circle, cutting the given line at *b*; through *b* and the centre *n*, draw the diameter *b n c*, and join *c* A, which will be the perpendicular required.



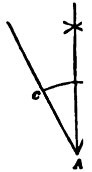
... ..., cut the arc in *c*,
rom *c*, cut the arc in *b*;
rom *c* and *b* as centres,
he same or any other radius,
be arcs cutting each other
then will the line A *t* be
rpendicular required.



—When the three sides of a triangle are in
of 3, 4, and 5 equal parts respectively, two of t
ight angle; and observe that in each of the pı
ıs, the perpendiculars may be continued be
ıes, if necessarily required.

'o bisect any given angle.

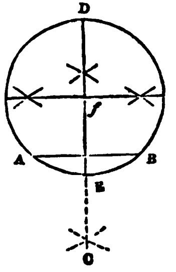
: the point A as a centre, with
ius less than the extent of the
escribe an arc, as *c d*; and
nd *d* as centres, describe arcs
each other at *b*; then will
A *b* bisect the angle as re-



find the centre of a circle that shall c
n points, not in a direct li...

intersection of the lines at *o* is the centre of the circle passing through *r*, *b*, *t*.

6. *To find the centre of a given circle.*

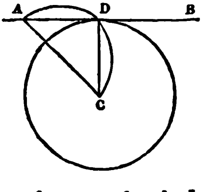


Bisect any chord in the circle, as A B, by a perpendicular C D; bisect also the diameter E D in *f*, and the intersection of the lines at *f* is the centre of the circle required.

7. *To find the length of any given arc of a circle.*

With the radius A C, equal to $\frac{1}{4}$th the length of the chord of the arc A B, and from A as a centre, cut the arc in C; also from B as a centre, with equal radius, cut the chord in *b*; draw the line C *b*, and twice the length of the line is the length of the arc nearly.

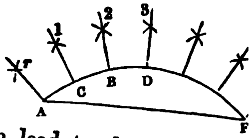
8. *Through any given point, to draw a tangent to a circle.*



Let the given point be at A: draw the line A C, on which describe the semicircle A D C; join A D, which, produced if necessary, is the tangent required.

9. *To draw from, or to the circumference of a circle*

... the desired number of equal p...
...h any radius
... the distance
divisions, de-
...s cutting each
A 1, B 1; C 2,
draw the lines



D 3, &c., which lead to the centre as

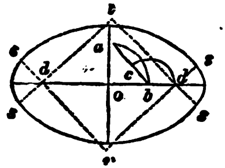
... the end lines, as A *r*, F *r*.

... radius C 2, describe the arc *r*, and with t...
from A or F as centres, cut the form...
... *r*, and the lines A *r*, F *r*, will tend to t...
...quired.

...given straight line, to describe an arc ...
altitude being given.

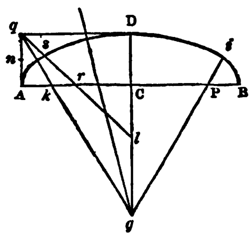
...e the given straight line, B *b* the give...
... D B, B E, and of any suitable materia...

11. *To describe an ellipse, having the two diameters given.*



On the intersection of the two diameters as a centre, with a radius equal to the difference of the semi-diameters, describe the arc *a b*, and from *b* as a centre, with half the chord *b c a*, describe the arc *c d*; from *o*, as a centre, with the distance *o d*, cut the diameters in *d*, *r*, *d*, *t*; draw the lines *r s*, *r s*, *t s*, *t s*, then from *r* and *t* describe the arcs *s s*, *s s*; also from *d* and *d* describe the smaller arcs *s s*, *s s*, which will complete the ellipse as required.

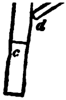
12. *To describe an elliptic arch, the width and rise of span being given.*



Bisect with a line at right angles the chord or span A B, erect the perpendicular A *q*, and draw the line *q* D equal and parallel to A C; bisect A C and A *q* in *r* and *n*, and draw the line *q r l*: and though not in the cut, draw also the line *n s* D; bisect *s* D with a line at right angles, and meeting the line C D produced in *g*; draw the line *g q*, make C P equal to C *k*, and draw the line *g* P *i*; then from *g* as a centre, with the radius *g* D, describe the arc *s* D *i*, and from *k* and P as centres, with the radius A *k*, describe the arcs A *s* and B *i*, which completes the arch as required. *Or*,

13. Bisect the chord A B, and fix at right angles any straight guide, as *b c*; prepare of any suitable

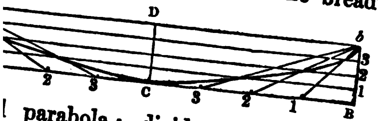
of the arch,
, and at the ex-
tracer *f*; move
keeping its end



de and the fixed pin to the chord, and describe one-half the arch required.

describe a parabola, the dimensions be

equal the length, and C D the breadth

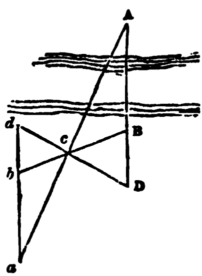


parabola: divide C A, C B into an
ual parts, also divide the perpendicular
nto the same number of equal parts;
and *b* draw lines meeting each division
C B, and a curve line drawn through
ion will form the parabola required.

in by measurement the length of any di-
gh intercepted

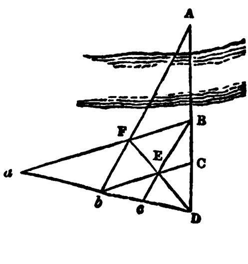
convenient radius, describe the arc *c c*, make the arc twice the radius in length, through which draw the line *d c e*, and on *e* describe another arc equal in length to once that radius, as *f f*; draw the line *e f r* equal to *e f d*; on *r* describe the arc *j j*, in length twice the radius; continue the line through *r*, *j*, which will be a right line, and *d e* or *e r*, will equal the distance between *d*, *r*, by which the distance between A and B is obtained as required.

16. *To ascertain the distance geometrically, of any inaccessible object on an equal plane.*



Let it be required to find the distance between A and B, A being inaccessible: produce the line in the direction of A B to any point, as D; draw the line D *d* at any angle to the line A B; bisect the line D *d* in *c*, through which draw the line B *b*, making *c b* equal to B *c*; join A *c*, and draw *d b a* meeting A *c*, produced in *a*. Then *b a*, equal to A B, is the distance required.

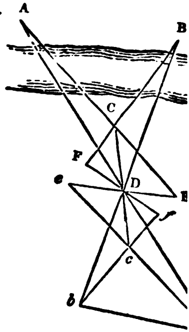
17. *Or otherwise,*



Produce A B to any point D, and bisect B D in C; through D draw D *a*, making any angle with D A, and take D *c*, D *b*, equal to D C and D B respectively; join B *c*, C *b*, and A *b*. Through E, the intersection of B *c*, C *b*, draw D E F meeting A *b* in

...y inaccessible. *... between two*

m any point C draw
ne C c, and bisect it
take any point E in
rolongation of A C,
raw the line E e,
; D e equal to D E;
manner take any
in the prolongation
nd make D f equal
Produce A D and
hey meet in a, and
and f c till they
b; then a b is

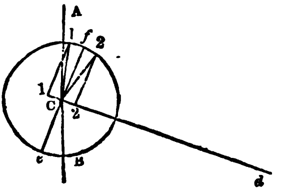


A B, or the distance between the objec

round piece of timber being given, ou
ut a beam of strongest section.

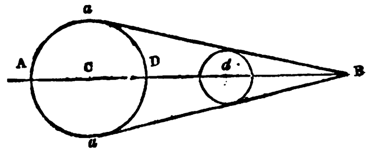
nto three equal parts any
the circle, as A d, d e, e C;
e, erect a perpendicular

of eccentric rod and travel of the valve being given.



Draw the right line A B, as the situation of the crank at commencement of the stroke; draw also the line C d, at the proper given angle of eccentric rod with the crank; then from C as centre, describe a circle equal to the travel of the valve; draw the line $e\ f$ at right angles to the line C d; draw also the lines 1 1, and 2 2, parallel to the line $e\ f$; and at a distance from $e\ f$ on each side, equal to the lap and lead of the valve, draw the angular lines C 1, C 2, which are the angles of eccentric with the crank, for forward or backward motion, as may be required.

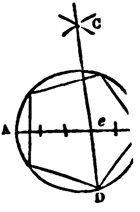
21. *The throw of an eccentric, and the travel of the valve in a steam engine, also the length of one lever for communicating motion to the valve, being given, to determine the proper length for the other.*



On any right line, as A B, describe a circle A D, equal to the throw of eccentric and travel of valve; then from C as a centre, with a radius equal to the length of lever given, cut the line A B, as at d, on which describe a circle, equal to the throw of eccentric or travel of valve, as may be required; draw the tangents B a, B a, cutting each other in the line A B, and d B is the length of the lever as required.

veı of a valve is equal to the sum
:hs of the two steam openings, and
excess of length more than just sufficient to
gs.

*› inscribe any regular polygon in a given c*ı



any diameter, as A B, into
equal parts as the polygon
d to have sides; from A and
·es, with a radius equal to
ter, describe arcs cutting
· in C; draw the line C D
the second point of di-
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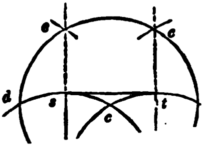
side of the polygon re-

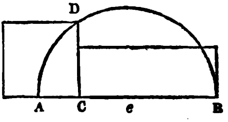
onstruct a square upon a given right li



nd B as centres,
lius A B, describe
›, B *c d*, and from
al radius describe
›ortion of a circle
rom *b*, *d*, cut the

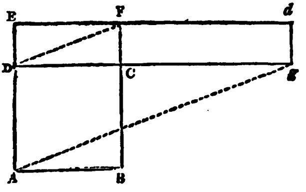
and describe the semicircle *e n* C; erect the perpendicular A *s*, or side of the square, then A *s t x* is the square of equal area as required.

25. *To form a square equal in area to a given rectangle.*



Let the line A B equal the length and breadth of the given rectangle: bisect the line in *e*, and describe the semicircle A D B; then from A with the breadth, or from B with the length of the rectangle, cut the line A B at C, and erect the perpendicular C D, meeting the curve at D, and C D is equal to a side of the square required.

26. *To find the length for a rectangle whose area shall be equal to that of a given square, the breadth of the rectangle being also given.*

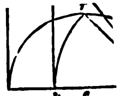


Let A B C D be the given square, and D E the given breadth of rectangle. Through E draw E F parallel to A B or D C; produce B C to F, and join D F. Through A draw A *g* parallel to D F, cutting D C produced in *g*, through which draw *g d* parallel to D E, meeting E F produced in *d*. E D *g d* is the rectangle required.

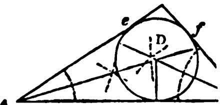
27. *To bisect any given triangle.*

Suppose A B C the given triangle: bisect one of

ɪl to A C, which will bisect
angle as required.

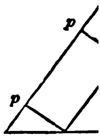


To describe a circle of greatest diameter
riangle.



ct the angles A and
draw the intersect-
s A D, B D, cutting
ther in D; then
as centre, with
tance D C, which is drawn perpendicul
scribe the circle, C *e f*, as required.

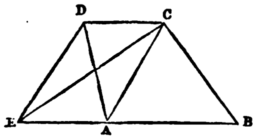
To form a rectangle of greatest
in a given triangle.



A B C be the given triangle:
ny two of its sides, as A B,
e and *d*; draw the line *e d*;
ight angles with the line *e d*,
lines *e p*, *d p*, and *e p p d*
ctangle required.

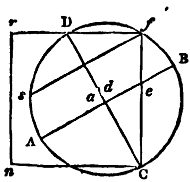
To make a rectangle equal to a given ...

31. *To make a triangle equal to a given quadrilateral, as* A B C D.



Prolong the line B A, and draw the line A C; draw also the line D E parallel to A C, and cutting the line B A in E; then draw the line E C, and C E B is the triangle required.

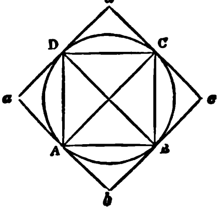
32. *To form a square nearly equal in area to a given circle.*



Let A C B D be the given circle: draw the diameters A B and C D at right angles to each other, bisect the radius *d* B in *e*, and draw the line C *e f*; draw also at right angles the lines C *n* and *f r*, making each equal to C *f*; join *n r*, and *n* C *f r* is the square as required.

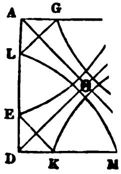
Note.—The line *s f* is equal to one-fourth the circumference of the circle nearly.

33. *To inscribe or describe a square within or without a given circle: also to form an octagon from a given square.*



1. Let A B C D be the given circle: draw the diameters A C, B D, at right angles to each other, and join A B, B C, C D, D A, which will complete the inscribed square: through the extremities of the same diameters draw *a b*, *c d*, parallel

- .. B C D be the given square. D
gonal lines A C and B D
ting in O; then with a
equal to A O, or half the
l, and with A as a centre,
e the arc E F, cutting the
f the square in E and F;
om B as a centre, describe
G H, and in the same



from C and D describe the arcs I K and
e lines L G, F I, H M, and K E, which,
G F, I H, M K, and E L, form the oct

form a square equal to two given squ
le equal to two given circles.

, A C, equal the sides of
squares, or diameters of
circles: make the angle
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which is the side of a
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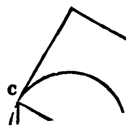
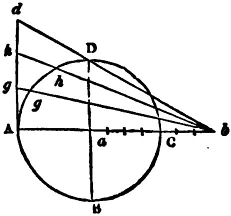
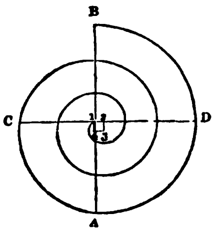


ference of which is required: draw at right angles the diameters A C, B D, divide the radius *a* C into four equal parts, and make C *b* equal to three of them; draw the tangent A *d* parallel to B D, draw the line *b* D *d*, then will A *d* be nearly a fourth of the whole circumference; and if lines be drawn from *b*, through points in the circumference, meeting the line A *d*, as *g g*, *h h*, &c., the corresponding parts will be equal to each other nearly.



36. *To draw a spiral with spaces of uniform distance.*

Bisect the height of the spiral, as A B, and divide either half into the number of spaces or revolutions required; then again subdivide any one space into four equal parts, one of which add to half the height of the spiral, and through the termination draw C D at right angles to A B, thus forming the centre of the spiral, around which and equal to one of the subdivisions form a square, its sides being parallel with the lines A B and C D, the angles of which are the centres from whence to describe the various curves; as from 1, with the distance 1 B, describe the curve B D; from 2, with the distance 2 D, describe D A; from 3, with the distance 3 A, describe A C, &c., &c., and from the same centres the spiral may be continued to any extent required.



the height
rm a square in
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respond with or
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square with lines
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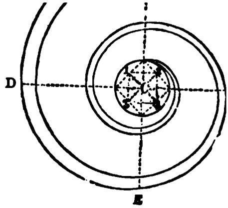
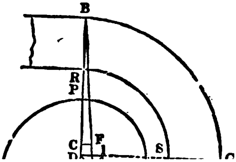


into six equal parts, which are the centr
h the volute is to be described: thus, fro
e distance 1 B, describe the curve B I
ith 2 D, describe D E; from 3, with 3
A, &c., approaching the centre by degre
olute is completed as required.

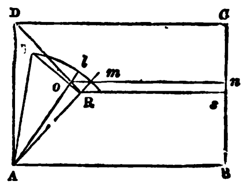
*draw a scroll for the termination of
&c.*

equal the given
raw A E perpen-
B, which divide
equal parts, and
one of them;
isect A B in C



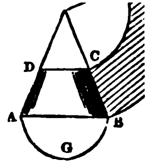
D O K, I O L, perpendicular to D O K; draw I K parallel to B A, K L parallel to I D, &c., meeting the diagonals; from D as a centre, with the distance D B, describe the arc B G; from I as a centre, with the distance I G, describe G E; from K, with the distance K E, describe K H, &c., proceeding in the same manner until the outside of the scroll is completed; make B R equal to the breadth of the rail; then from D, with the distance D R, describe the arc R S; from I, and distance I S, describe S T; and from T, with K T, describe T U, which completes the scroll as required.

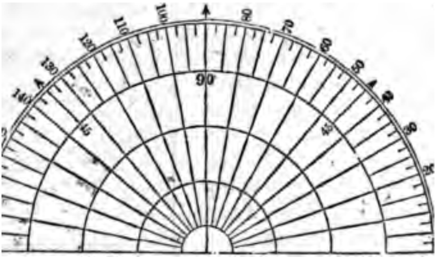
39. *To find the various angles and proper dimensions of materials whereby to construct any figure whose form is the frustum of a proper or inverted pyramid, as hipped roofs, mill hoppers, &c., &c.*



Let A B C D be the given dimensions of plan for a roof, the height R T also being given; draw the diagonal A R, meeting the top or ridge R *s* on plan; from R, at right angles with A R and equal to the required height, draw the line R T, then T A, equals the length of the struts or corners of the roof; from A, with the distance A T, describe an arc T *l*, continue the diagonal A R until it cuts the arc T *l*, through which, and parallel with the ridge R *s*, draw the line *m n*, which determines the required breadth for each side of the roof: from A, meeting the line *m n*, draw the line A *o*, or proper angle for the end of each board by which the roof might require to be covered; and the angle at T is what the boards require to be made in the direction of their thickness, when the corners or angles require to be mitred.

rom E as centre, with the E C, describe the arc C H; om E, with the radius E B, e the arc B I; make B I in length to twice A G B, he line E I, and B C I H is m of plate as required.





Sector from which angles may be obtained.

GEOMETRY APPLIED TO MECHANICS.

To delineate a vee-threaded screw, the

Fig. 2.

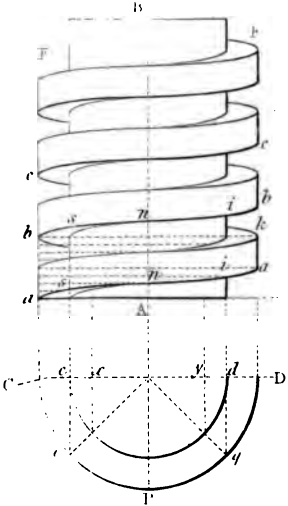


Fig. 3

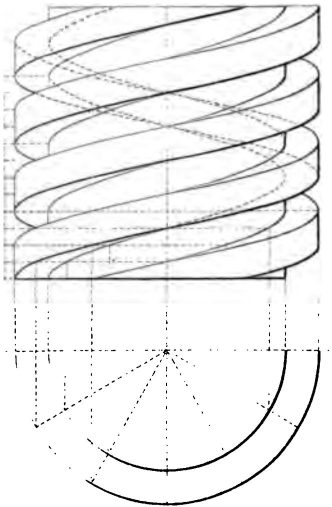
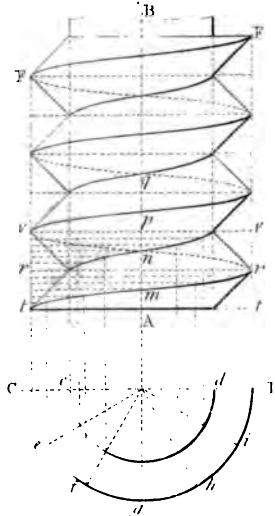


Fig. 1.



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into any number of equal parts, as C, *e*, *f*, *g*, *h*, *i*, D, from which draw lines parallel to the line A B; divide the lines C F, D F, into equal divisions of half the required pitch or consecutive threads, as *t*, *r*, *v*, &c.; draw the lines *t t*, *r r*, *v v*, &c., parallel with the diameter C D, and subdivide any two connected divisions into the same number of equal parts contained in both semicircles, from which draw lines meeting the vertical lines; then by hand, or otherwise, and through the intersections, draw the waved lines, *m*, *n*, *p*, *q*, &c., and a thread of the screw is delineated as required.

Note.—The same process might be continued throughout the whole length of the screw, but it is much more convenient, when the proper curves are obtained, to form a suitable ruler: lay it in its proper situation upon each division, and draw the lines as required.

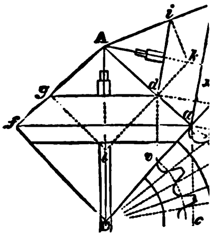
42. *To delineate a square-threaded screw, the pitch and diameter of screw being given.* (See Plate A, fig. 2.)

On the line A B representing the centre of the screw, describe the semicircles C D, *c d*, equal to the diameters at the tops and bottoms of the threads; divide each semi-circumference into four equal parts, draw lines from each and parallel to the line A B; draw also the lines C F, D F, which divide into the proper required pitch, as *a a*, *b b*, *c c*, &c.; divide any two connected pitches or divisions, as *a*, *b*, into four equal parts, from which draw lines parallel to the diameter C D, meeting the vertical lines *o*, P, *q*, and forming intersections through which the waved lines *s*, *n*, *i*, *s*, *n*, *i*, or tops of the threads, must be traced by hand or otherwise; draw also the lines *x*, *y*, forming intersections through which to trace the curve surface exhibited between and caused by the angular return

- ... of fig. 2, but intended, by displace
ylinder, to delineate a continuous vein o
ı its proper form around the whole circ
.ence, being deemed by the preceding figı
ufficiently described, further elucidation m
idered unnecessary.

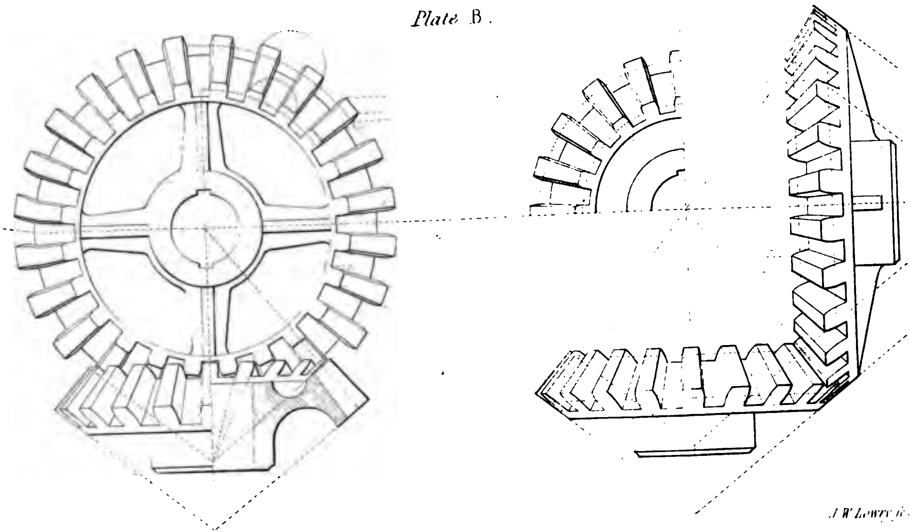
43. *To determine the proper forms for*
vel wheels, the required angle of the shaft
eters of the wheels being given.

Draw at the given angles lines represe
afts on which the wheels are to be fixed
C; make the lines
, *a c*, parallel with
l at a distance from
, A C, equal to the
iusofeachrespective
el at the greatest
h circle; draw the
A *a* through the
section at *d*; then
a at right angles



ILLUSTRATIONS TO THE DRAWING OF BEVEL WHEELS.

Plate B.



J W Lowry fc.

the radius B a, C a, describe portions of circles, as a G, a H, on which describe the greatest dimensions of, and proper form of the teeth; then from d, and parallel with A B, A C, draw the lines a v, a x, cutting the line C B in v and x; from B and C, with the distances C v, B x, describe the portions of circles, which determines the dimensions of the teeth on the interior pitch circle, and completes the proper forms of the wheels as required.

Proportions for the construction of toothed wheels.

Length of the teeth $= \frac{5}{7}$ of the pitch.
Thickness „ $= \frac{4}{9}$ do.
Breadth on face $= 2\frac{1}{2}$ times the pitch.

$$\left.\begin{array}{l}\text{Edge of the rim}\\ \text{Projecting rib inside do.}\\ \text{Thickness of flat arms}\end{array}\right\}\text{each } \tfrac{4}{9} \text{ of the pitch.}$$

Breadth of arms at rim $= 2$ teeth and $\frac{1}{4}$ the pitch, increasing in breadth towards the centre of the wheel, in the proportion of $\frac{1}{2}$ an inch for every foot in length.

Thickness of the ribs or feathers on the arms $= \frac{1}{4}$ of the pitch.

Thickness of metal around the eye, or centre, $= \frac{7}{9}$ of the pitch.

Wheels and other circular bodies are very conveniently transferred from plan to that of a projected perspective by means of a peculiar appropriation of straight lines, commonly called orthographic projection, the principle of which will be readily understood by reference to the diagrams and illustrations given for the purpose in Plate C.

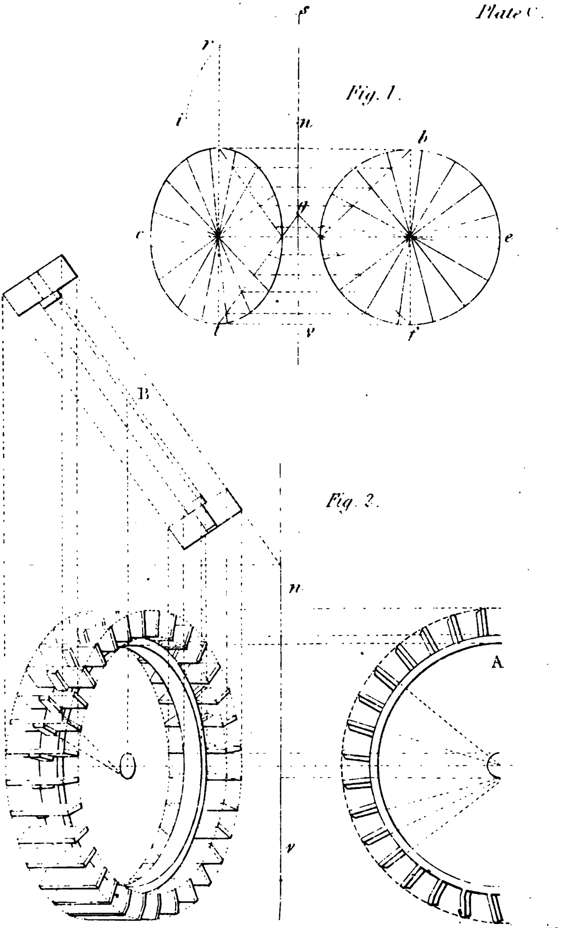
Fig. 1 is a circle divided into equal parts, and its form in projection is required, v n being supposed the line of intersection: parallel with the diameter of the

, *c*, which determines the breadth of the
rojected form of the circle, and which
n as described (page 5, fig. 12): hence
: lines being so distinctly described, by
ion of the diagrams, further explanation
sary.

;. 2 is a projected representation of an un
-wheel, of which A is the plan, *v n* the
ection, and B the diameter and breadth,
per angle or inclination, as determined
ples of the diagrams: the breadth of the
nd and formed as there described, and th
: illustration, or fig. 2, whereby to obt
r angles for projection, render sufficien
the proper mode by which the represe
:ted.

ORTHOGRAPHIC PROJECTION.

Plate C.



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DECIMAL ARITHMETIC.

Decimal Arithmetic is the most simple and explicit mode of performing practical calculations; on account of its doing away with the necessity of fractional parts in the fractional form, thereby reducing long and tedious operations to a few figures, arranged and worked in all respects according to the usual rules of common arithmetic.

Decimals simply signify tenths: thus, the decimal of a foot is the tenth part of a foot, the decimal of that tenth is the hundredth of a foot, the decimal of that hundredth is the thousandth of a foot, and so might the divisions be carried on and lessened to infinity; but in practice it is seldom necessary to take into account any degree of less measure than a one-hundredth part of the integer or whole number. And, as the entire system consists in supposing the whole number divided into tenths, hundredths, thousandths, &c., no peculiarity of notation is required, otherwise than placing a mark or dot, to distinguish between the whole and any part of the whole: thus 34·25 gallons signify 34 gallons 2 tenths and 5 hundredths of a gallon; 11·04 yards signify 11 yards and 4 hundredths of a yard; 16·008 shillings signify 16 shillings and 8 thousandth parts of a shilling: from which it must appear plain, that ciphers on the right hand of decimals are of no value whatever; but placed on the left hand, they diminish the decimal value in a tenfold proportion,—for ·6 signifies 6 tenths; ·06 signifies 6 hundredths; and ·006 signifies 6 thousandths, of the integer or whole number.

REDUCTION.

Reduction means the construing or changing of

valent value.

ule 2. Multiply the decimal by successi
bers, such as to cause the decimals in
uct to be all 0. The integer prefixed
be the numerator, and the product of th
s the denominator of the equal fracti
r the figures of the decimal write 1, f
many 0's.

. 1. Required the decimal equival
al of equal value, to $\frac{3}{12}$ of a foot.

$$\frac{3 \cdot 00}{12} = \cdot 25, \text{ the decimal required.}$$

. 2. Reduce the fraction $\frac{1}{8}$ of an inch to
f equal value.

$$\frac{1 \cdot 000}{8} = \cdot 125, \text{ the decimal required.}$$

3. What is the decimal equivalent to
?

$$\frac{7 \cdot 000}{8} = \cdot 875, \text{ the decimal equivalent.}$$

Ex. 5. What is the value of ·625 of a cwt.?

	·625
Multiply by 4 qrs.	4
	2·500
× 28 lbs.	28
	14·000 = 2 quarters and 14 lbs., the value required.

Ex. 6. Ascertain the value of ·875 of an imperial gallon.

	·875
Multiply by 4 quarts	4
	3·500
× 2 pints	2
	1·000 = 3 quarts and 1 pint, the value required.

Ex. 7. What is the value of ·525 of a £. sterling?

	·525
Multiply by 20 sh.	20
	10·500
× 12 pence	12
	6·000 = 10 shillings and 6 pence, the value required.

Independent of the mark or dot which distinguishes between integers and decimals, the fundamental rules, viz., Addition, Subtraction, Multiplication, and Division, are in all respects the same as in Simple Arithmetic; and an example in each, illustrative of placing the separating point, will no doubt render the whole system sufficiently intelligible, even to the dullest capacity.

$$\begin{array}{r} 16{\cdot}625 \\ 11{\cdot}4 \\ 20{\cdot}7831 \\ 12{\cdot}125 \\ 8{\cdot}04 \\ 7{\cdot}002 \\ \hline 75{\cdot}9751 \end{array} = \text{the sum requi}$$

Ex. 2. Subtract 119·80764 from

$$\begin{array}{r} 234{\cdot}98276 \\ 119{\cdot}80764 \\ \hline 115{\cdot}17512 \end{array} = \text{the remainder}$$

Ex. 3. Multiply 62·10372 by 16

$$\begin{array}{r} 62{\cdot}10372 \\ 16{\cdot}732 \\ \hline 12420744 \\ 18631116 \\ 43472604 \\ 37262232 \end{array}$$

Ex. 4. Divide 39·375 by 9·25.

```
9·25) 39·375 (4·256 = the quotient required.
      3700
      ----
       2375
       1850
       ----
        5250
        4625
        ----
         6250
         5550
         ----
          700
          ====
```

Observe that the number of decimals in the divisor and quotient together, must be equal to the number in the dividend.

Note.—The operation might be still continued, so as to reduce the quotient to a degree of greater exactitude, but in practice it is quite unnecessary, being even now reduced to a measure of greater nicety than is commonly required.

Definitions of Arithmetical signs employed in the following calculations, which ought to be particularly attended to.

$=$ sign of equality, and signifies equal to, as 3 added $4 = 7$.

$+$	„	addition	„	plus or more, as $5 + 3 = 8$.
$-$	„	subtraction	„	minus or less, as $8 - 3 = 5$.
$\times$	„	multiplication	„	multiplied by, as $8 \times 3 = 24$.
$\div$	„	division	„	divided by, $24 \div 4 = 6$ or $\frac{24}{4} = 6$.
$: :: :$		proportion	„	that 2 is to 3 as 4 is to 6, &c.
$\sqrt{}$	„	square root	„	evolution, or the extr^n. of roots;
$\sqrt[3]{}$	„	cube root	„	thus, $\sqrt{64} = 8$ and $\sqrt[3]{64} = 4$.
4^2	„	to be squared	„	involution, or the raising of powers;
4^3	„	to be cubed	„	thus, $4^2 = 16$, and $4^3 = 64$.

$\overline{3+5} \times 4 = 32$ — that, 3 plus 5, or 8 multiplied by $4 = 32$.

$\sqrt{5^2 - 3^2} = 4$ — 5 squared, minus 3 squared, the square root of the remainder $= 4$.

$\sqrt[3]{\dfrac{20 \times 12}{30}} = 2$, 20 multiplied by 12, and divided by 30, the cube root of the quotient $= 2$.

.... = 1 fu
3 furlongs, 1760 yards, or 5280 feet... = 1 m

Measures of surface, or square measur

144 square inches .... = 1 sq
9 square feet .... = 1 sq
30¼ square yards.......................... = 1 squ
40 square poles .... = 1 roo
roods, or 4840 square yards .... = 1 acr

Measures of solidity, or cubic measure.

1728 cubic inches .... = 1 cub
27 cubic feet .... = 1 cub

Measures of capacity.

LIQUIDS.

365 cubic inches .... = 1 gill.
gills .... = 1 pint
pints .... = 1 quar
quarts, or 277¼ cubic inches .... = 1 gallo

GRAIN, FRUITS, &c.

allons .... = 1 peck
ecks, or 2218·192 cubic inches...... = 1 bush
ushels .... = 1 quar
uarters.................................... = 1 load.

easures of weight.

TROY.

rains ....

BRITISH SPECIAL MEASURES.

1. *Lineal measures for land.*

7·92 inches	=	1 link.
100 links, or 22 yards	=	1 chain.
80 chains	=	1 mile.
69·121 miles	=	1 geog. degree.

2. *Square measures for land.*

62·7264 square inches	=	1 square link.
10,000 square links	=	1 square chain.
10 square chains	=	1 acre.

3. *Nautical measures.*

6082·66 feet	=	1 nautical mile.
3 miles	=	1 league.
20 leagues	=	1 degree.
360 degrees	=	the earth's circumference.

Miscellaneous special measures.

6 lineal feet	=	1 fathom.	
100 square feet	=	1 square of flooring.	
272 sq. feet, at 14 in. in thickness	=	1 rod of brick-work.	
600 square feet of inch boards	=	1 load.	
40 cubic feet of round timber 50 cubic feet of hewn timber	=	1 ton or load.	
40 cubic feet	=	1 ton of shipping.	
120 deals	=	1 hundred.	
120 nails	=	1 hundred.	
1200 do.	=	1 thousand.	
500 bricks	=	1 load.	
32 bushels of lime	=	1 do.	
36 do. sand	=	1 do.	
19½ cwt.	=	1 fother of lead.	
108 cubic feet	=	1 stack of wood.	
42 gallons	=	1 tierce	old wine measure.
63 do.	=	1 hogshead	
84 do.	=	1 puncheon	
126 do.	=	1 pipe	
252 do.	=	1 tun	
36 do.	=	1 barrel	old ale measure.
54 do.	=	1 hogshead	
72 do.	=	1 puncheon	
108 do.	=	1 butt	

Square inches	„	·007	=	square feet
„ yards	„	·0002067	=	acres.
Circular inches	„	·00546	=	square feet
Cylindrical inches	„	·0004546	=	cubic feet.
„ feet	„	·02909	=	cubic yard
Cubic inches	„	·00058	=	cubic feet.
„ feet	„	·03704	=	cubic yard
„ „	„	6·232	=	imperial ga
„ inches	„	·003607	=	„ „
Cylindrical feet *	„	4·895	=	„ „
„ inches	„	·002832	=	„ „
Cubic inches	„	·263	=	lbs. avᵉ. of
„ „	„	·281	=	„ wrou
„ „	„	·283	=	„ steel.
„ „	„	·3225	=	„ coppe
„ „	„	·3037	=	„ brass.
„ „	„	·26	=	„ zinc.
„ „	„	·4103	=	„ lead.
„ „	„	·2636	=	„ tin.
„ „	„	·4908	=	„ mercu
Cylindrical inches	„	·2065	=	„ cast ir
„	„	·2168	=	„ wroug
„	„	·2223	=	„ steel.
	„	·2533	=	„ coppe
„	„	·2385	=	„ brass.
„	„	·2042	=	„ zinc.
„	„	·3223	=	„ lead.
„	„	·207	=	tin

IMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASURES.

One inch, the integer or whole number.

875	are equal to	$\frac{7}{8}$ & $\frac{3}{32}$	·625	are equal to	$\frac{5}{8}$	·28125	are equal to	$\frac{1}{4}$ & $\frac{1}{32}$
75		$\frac{7}{8}$ & $\frac{1}{16}$	·59375		$\frac{1}{2}$ & $\frac{3}{32}$	·25		$\frac{1}{4}$
625		$\frac{7}{8}$ & $\frac{1}{32}$	·5625		$\frac{1}{2}$ & $\frac{1}{16}$	·21875		$\frac{1}{8}$ & $\frac{3}{32}$
5		$\frac{7}{8}$	·53125		$\frac{1}{2}$ & $\frac{1}{32}$	·1875		$\frac{1}{8}$ & $\frac{1}{16}$
375		$\frac{3}{4}$ & $\frac{3}{32}$	·5		$\frac{1}{2}$	·15625		$\frac{1}{8}$ & $\frac{1}{32}$
25		$\frac{3}{4}$ & $\frac{1}{16}$	·46875		$\frac{3}{8}$ & $\frac{3}{32}$	·125		$\frac{1}{8}$
125		$\frac{3}{4}$ & $\frac{1}{32}$	·4375		$\frac{3}{8}$ & $\frac{1}{16}$	·09375		$\frac{3}{32}$
		$\frac{3}{4}$	·40625		$\frac{3}{8}$ & $\frac{1}{32}$	·0625		$\frac{1}{16}$
875		$\frac{5}{8}$ & $\frac{3}{32}$	·375		$\frac{3}{8}$	·03125		$\frac{1}{32}$
75		$\frac{5}{8}$ & $\frac{1}{16}$	·34375		$\frac{1}{4}$ & $\frac{3}{32}$			
625		$\frac{5}{8}$ & $\frac{1}{32}$	·3125		$\frac{1}{4}$ & $\frac{1}{16}$			

One foot, or 12 inches, the integer.

66	are equal to	11 inches.	·4166	are equal to	5 in.	·0625	are equal to	$\frac{3}{4}$ of in.
38		10 "	·3333		4 "	·05208		$\frac{5}{8}$ "
		9 "	·25		3 "	·04166		$\frac{1}{2}$ "
66		8 "	·1666		2 "	·03125		$\frac{3}{8}$ "
33		7 "	·0833		1 "	·02083		$\frac{1}{4}$ "
		6 "	·07291		$\frac{7}{8}$ "	·01041		$\frac{1}{8}$ "

One yard, or 36 inches, the integer.

22	are equal to	35 inches.	·6389	are equal to	23 inches.	·3055	are equal to	11 inches.
44		34 "	·6111		22 "	·2778		10 "
67		33 "	·5833		21 "	·25		9 "
89		32 "	·5556		20 "	·2222		8 "
11		31 "	·5278		19 "	·1944		7 "
33		30 "	·5		18 "	·1667		6 "
56		29 "	·4722		17 "	·1389		5 "
78		28 "	·4444		16 "	·1111		4 "
		27 "	·4167		15 "	·0833		3 "
22		26 "	·3889		14 "	·0555		2 "
44		25 "	·3611		13 "	·0278		1 "
67		24 "	·3333		12 "			

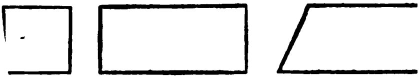
MENSURATION.

MENSURATION is that branch of which is employed in ascertaining th solidities, and capacities of bodies, capa. measured.

1. MENSURATION OF SURFACI

To measure or ascertain the quantity o) ny right-lined figure whose opposite sides (each other, as a

Square, Rectangle, Rhomboi



Rule.—Multiply the length by the br duct is the area or superficial contents.

Application of the rule to practical pu

. The side of a square piece of board is ngth; requi

3. Required the number of square yards in a floor whose length is $13\frac{1}{2}$, and breadth $9\frac{3}{4}$ feet.

$13{\cdot}5 \times 9{\cdot}75 = 131{\cdot}625 \div 9 = 14{\cdot}625$ square yards.

Note 1.—The above rule is rendered equally applicable to figures whose sides are not parallel to each other, by taking the mean breadth as that by which the contents are to be estimated.

2. The square root of any given sum equals the side of a square of equal area.

3. Any square whose side is equal to the diagonal of another square, contains double the area of that square.

4. Any sum or area (of which to form a rectangle) divided by the breadth, the quotient equals the length; or divided by the length, the quotient equals the breadth of the rectangle required.

TRIANGLES.

Any two sides of a right-angled triangle being given, to find the third side.

Rule 1.—Add together the squares of the base and perpendicular, and the square root of the sum is the hypotenuse or longest side.

Rule 2.—Add together the hypotenuse and any one side, multiply the sum by their difference, and the square root of the product equals the other side.

Application to practical purposes.

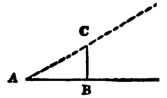
1. Wanting to prop a building with raking shores, the top ends of which to be 25 feet from the ground, and the bottom ends, 16 feet from the base of the building; what must be their length, independent of any extra length allowed below the surface of the ground?

$\overline{25^2 + 16^2} = \sqrt{881} = 29{\cdot}6816$ feet, or $\cdot 6816 \times 12 = 8$ inches; consequently, 29 feet 8 inches nearly.

2. From the top of a wall 18 feet in height, a line was stretched across a canal for the purpose of ascer-

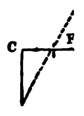
iangles similar to each other are propor other; hence their utility in ascertai its and distances of inaccessible objects.

ius, suppose the height inaccessible object D is red, I find by means of staffs or otherwise, the t of the perpendicular ind the length of the line A B; also the distance from A to t : object G D;

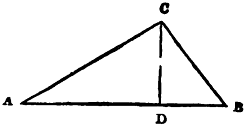


n A B : B C : : A G : G D. And suppose A B=(
B C=2 feet, and A G=150;
6 : 2 : : 150 : 50 feet, the height of D from G

iin, suppose the inaccessible dis- B A be required, make the line C, at right angles, and B C of or four equal parts of any con- t distance, through one of which a line with the object A, deter- he triangle C D F, then the pro- ı will be as



1. The base of the triangle A D B is $11\frac{3}{32}$ inches in length, and the height D C, $3\frac{3}{8}$ inches; required the area.



$\frac{3}{32}$=·09375 and $\frac{3}{8}$=·375 (see page 31):

hence $\frac{11{\cdot}09375 \times 3{\cdot}375}{2}$=18·72075 square inches, the area.

2. The base of a triangle is 53 feet 3 inches, and the perpendicular 7 feet 9 inches; required the area or superficies.

$\frac{53{\cdot}25 \times 7{\cdot}75}{2}$=206·34375 square feet, the area.

When only the three sides of a triangle can be given, to find the area.

Rule.—From half the sum of the three sides, subtract each side severally; multiply the half sum and the three remainders together, and the square root of the product is equal to the area required.

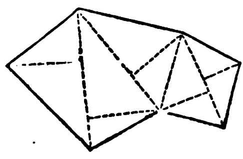
Required the area of a triangle whose three sides are respectively 50, 40, and 30 feet.

$\frac{50+40+30}{2}$=60, or half the sum of the three sides.

60−30=30, first difference,
60−40=20, second difference,
60−50=10, third difference;

then 30 × 20 × 10 × 60= $\sqrt{360000}$=600, the area required.

Triangles are employed to great advantage in determining the area of any rectilineal figure, as the annexed, and by which the measurement is rendered comparatively simple.



...es, and half the product is the area.

...gle at ...tre.	Angle at circum.	Perpen. side being 1.	Length of side, radius being 1.	Radius of circle, side being 1.	Radius of circle, per. being 1.	Area, side being 1.
...0°	60°	0·2886	1·73	·579	2	0·4330
[illegible]	90	0·5	1·412	·705	1·41	1
[illegible]	108	0·6882	1·174	·852	1·238	1·7204
	120	0·8660	1	1	1·156	2·5980
[illegible]	128$\frac{4}{7}$	1·0382	·867	1·16	1·11	3·6339
	135	1·2071	·765	1·307	1·08	4·8284
	140	1·3737	·681	1·47	1·062	6·1818
	144	1·5388	·616	1·625	1·05	7·6942

Application of the Table.

1. The radius of a circle being $6\frac{1}{2}$ feet, required the side of the greatest heptagon that may be inscribed therein.

$\cdot 867 \times 6\cdot 5 = 5\cdot 6355$, or 5 feet $7\frac{1}{2}$ inches nearly.

2. Each side of a pentagon is required to be 9 feet; required the radius of circumscribing circle.

$\cdot 852 \times 9 = 7\cdot 668$, or 7 feet 8 inches.

3. A perpendicular from the centre to either side of an octagon is required to be 12 feet; what must be the radius of circumscribing circle?

$1\cdot 08 \times 12 = 12\cdot 96$, or 12 feet $11\frac{1}{2}$ inches.

4. Each side of a hexagon is $4\frac{1}{2}$ yards; required its superficial contents.

$4\frac{1}{2}^2 \times 2\cdot 598 = 52\cdot 6095$ square yards.

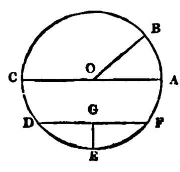
THE CIRCLE AND ITS SECTIONS.

Observations and Definitions.

1. The circle contains a greater area than any other plane figure bounded by the same perimeter or outline.

2. The areas of circles are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

3. The radius of a circle is a straight line drawn from the centre to the circumference, as O B.



4. The diameter of a circle is a straight line drawn through the centre, and terminated both ways at the circumference, as C O A.

meter, as C E A.

A segment is any portion of a circle cut c
ırd, as D E F.

. A sector is a part of a circle cut off b
as A O B.

General rules in relation to the circle.

Multiply the diameter by 3·1416, the pr
e circumference.

Multiply the circumference by ·31831, th
is the diameter.

Multiply the square of the diameter by ·
roduct is the area.

Multiply the square root of the area by 1·1
roduct is the diameter.

Multiply the diameter by ·8862, the prod
ide of a square of equal area.

Multiply the side of a square by 1·128, the
is the diameter of a circle of equal area.

lication of the rules as to purposes of prac

being 274·89 inches, required the circle's diameter corresponding thereto.

$\cdot 274 \cdot 89 \times \cdot 31831 = 87 \cdot 5$ inches diameter.

Or, what is the diameter of a circle when the circumference is 39 feet?

$\cdot 31831 \times 39 = 12 \cdot 41409$ feet, and $\cdot 41409 \times 12 = 4 \cdot 96908$ inches, or 12 feet 5 inches, very nearly the diameter.

3. The diameter of a circle is $3\frac{3}{4}$ inches; what is its area in square inches?

$3 \cdot 75^2 = 14 \cdot 0625 \times \cdot 7854 = 11 \cdot 044$, &c. inches area.

Or, suppose the diameter of a circle 25 feet 6 inches, required the area.

$25 \cdot 5^2 = 650 \cdot 25 \times \cdot 7854 = 510 \cdot 706$, &c. feet, the area.

4. What must the diameter of a circle be, to contain an area equal to 706·86 square inches?

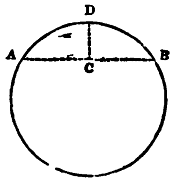
$\sqrt{706 \cdot 86} = 26 \cdot 586 \times 1 \cdot 12837 = 29 \cdot 998$ or 30 inches, the diameter required.

5. The diameter of a circle is $14\frac{1}{4}$ inches; what must I make each side of a square, to be equal in area to the given circle?

$14 \cdot 25 \times \cdot 8862 = 12 \cdot 62835$ inches, length of side required.

A chord and versed sine given to find the diameter.

Rule.—Divide the sum of the squares of half the chord and versed sine, by the versed sine; the quotient is the diameter.



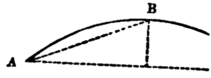
1. The chord of a circle A B equal $6\frac{1}{2}$ feet, and the versed sine C D equal 2 feet; required the circle's diameter.

$\frac{1}{2}(6 \cdot 5) = 3 \cdot 25$, and $3 \cdot 25^2 + 2^2 = 7 \cdot 28125$ feet diameter.

$1{\cdot}25 \times 2$

o find the length of any given arc of a c

ule.—From eight times the chord of subtract the chord of the whole arc, l of the remainder is equal the length of equired the length ıe arc A B C, the d A B of half the arc ; 4 feet, 3 inches, :hord A C of the whole arc 8 feet 4 inch

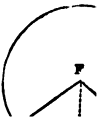


$25 \times 8 = 34$, and $34 - 8{\cdot}333 = \frac{25{\cdot}667}{3} = 8{\cdot}555$ fee length of the arc.

find the area of the sector of a circle.

ıle.—Multiply the length of the arc by its ıalf the product is the area.

e length of the arc A C B $9\frac{1}{2}$ feet, and the radii F A, equal each 7 feet; required ·ea.



$\times 7 = 65{\cdot}5 \div 2 = 32{\cdot}75$, the area

Thus, suppose the area of the segment A C B A is required, and that the length of the arc A C B equal $9\frac{3}{4}$ feet, F A and F B each equal 7 feet, and the chord A B equal 8 feet 4 inches, also the perpendicular *e* F equal $3\frac{3}{4}$ feet.

$$\frac{9{\cdot}75\times 7}{2}=34{\cdot}125 \text{ feet, the area of the sector.}$$

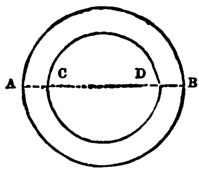
$$\frac{8{\cdot}333\times 3{\cdot}75}{2}=15{\cdot}624 \text{ feet, area of the triangle.}$$

And $34{\cdot}125-15{\cdot}624=18{\cdot}501$ feet, the area of the segment.

To find the area of the space contained between two concentric circles.

Rule.—Multiply the sum of the inside and outside diameters by their difference, and by ·7854; the product is the area.

1. Suppose the external circle A B equal 32 inches, and internal circle C D equal 28 inches; required the area of the space contained between them.



$\overline{32+28}=60$, and $32-28=4$; hence $60\times 4\times{\cdot}7854=188{\cdot}496$ in. the area.

2. The exterior diameter of the fly-wheel of a steam engine is 20 feet, and the interior diameter $18\frac{1}{2}$ feet; required the area of the surface or rim of the wheel.

$\overline{20+18{\cdot}5}=38{\cdot}5$, and $20-18{\cdot}5=1{\cdot}5$; hence $38{\cdot}5\times 1{\cdot}5\times{\cdot}7854$ $=45{\cdot}35$, &c. feet, the area.

To find the area of an ellipse or oval.

Rule.—Multiply the longest diameter by the shortest, and the product by ·7854; the result is the area.

An oval is 25 inches by 16·5; what are its superficial contents?

... ... multiply the base by the perpen(
ght, and two-thirds of the product is the ar
What is the area of a parabola whose base
and height 12?

$$20\times12=\frac{240\times2}{3}=160 \text{ feet, the area.}$$

Note.—Although the whole of the preceding pr
cations or examples are given in measures of f
s, these being considered as the most generally fa
the rules are equally applicable to any other u
urement whatever, as yards, chains, acres, &c. &c.

MENSURATION OF THE SUPERFICIES, SO DITIES, AND CAPACITIES OF BODIES.

To find the solidity or capacity of any figu ubical form.

Rule.—Multiply the length of any one side b
lth and by the depth or distance to its opp
the product is the solidity or capacity, in (
of measurement.

pplication of the rule to practical ...

capacity in cubic feet, also its capacity in British imperial gallons.

$8{\cdot}5 \times 5{\cdot}25 \times 4 = 178{\cdot}5$ cubic feet, and $178{\cdot}5 \times 6{\cdot}232$ (see Table of Decimal Approximations, p. 30) $= 1112{\cdot}412$ gallons.

3. A rectangular cistern capable of containing 520 imperial gallons is to be $7\frac{1}{4}$ feet in length, and $4\frac{1}{2}$ feet in width; it is required to ascertain the necessary depth.

$7{\cdot}25 \times 4{\cdot}5 \times 6{\cdot}232 = 203{\cdot}318$, and $\frac{520{\cdot}000}{203{\cdot}318} = 2{\cdot}557$ feet, or 2 feet $6\frac{2}{3}$ inches nearly.

4. A rectangular piece of cast iron, 20 inches long and 6 inches broad, is to be formed of sufficient dimensions to weigh 150 lbs.; what will be the depth required?

$20 \times 6 \times {\cdot}263$ (see Table of Decimal Approximations, Cast Iron, p. 30) $= 31{\cdot}96$, and $\frac{150}{31{\cdot}96} = 4{\cdot}69$ in., or 4 and $\frac{11}{16}$ in., the thickness required.

To find the convex surface, and solidity or capacity of a cylinder.

Rule. 1.—Multiply the circumference of the cylinder by its length or height; the product is the convex surface.

Rule 2.—Multiply the area of the base into the length or height; and the product is the cylinder's solidity or capacity, as may be required.

Application of the rules.

1. The circumference of a cylinder is $37\frac{1}{2}$ inches, and its length $54\frac{3}{4}$ inches; required the convex surface in square feet.

$54{\cdot}75 \times 37{\cdot}5 \times {\cdot}007$ (see Table of Approximations) $= 14{\cdot}371$ square feet.

2. A cylindrical piece of timber is 9 inches dia-

and $10\frac{1}{2}$ feet from the bottom to the sur water; how many imperial gallons are t tained?

$4{\cdot}75^2 \times 16{\cdot}5 \times 4{\cdot}895 = 1822{\cdot}162$ gallon

4. Again, suppose the well's diameter and its entire depth 35 feet; required th in cubic yards of material excavated in its

$4{\cdot}75^2 \times 35 \times {\cdot}02909 = 22{\cdot}973$ cubic yard

5. I have a cylindrical cistern capabl ing 7068 gallons, and its depth is 10 fe want to replace it with one of an equal capable of holding 12,500 gallons; what r diameter?

$4{\cdot}895 \times 10 = 48{\cdot}95$, and $\frac{12500}{48{\cdot}95} = \sqrt{255{\cdot}3} = 15{\cdot}9$ 15 feet $11\frac{3}{8}$ inches.

6. A cylindrical piece of lead is required diameter, and 168 lbs. in weight; what m length in inches?

$7{\cdot}5^2 \times {\cdot}3223 = 18$, and $\frac{168}{18} = 9{\cdot}3$ inches.

Application of the rule.

1. Required the length of the thread or screw twisting round a cylinder 22 inches in circumference $3\frac{1}{2}$ times, and extending along the axis 16 inches.

$22 \times 3{\cdot}5 = 77^2 = 5929$, and $16^2 = 256$; then $\sqrt{5929 + 256} = 78{\cdot}64$ inches.

2. The well of a winding staircase is 5 feet diameter, and height to the top landing 25 feet, the hand-rail is to make $2\frac{1}{2}$ revolutions; required its length.

5 feet diameter $= 15{\cdot}7$ feet circumference.
$15{\cdot}7 \times 2{\cdot}5 = 39{\cdot}25^2 = 1540{\cdot}5625$, and $25^2 = 625$; then
$\sqrt{1540 + 625} = 46{\cdot}5$ feet, the length required.

To find the convex surface, solidity, or capacity of a cone or pyramid.

Rule 1.—Multiply the circumference of the base by the slant height, and half the product is the slant surface.

Rule 2.—Multiply the area of the base by the perpendicular height, and one-third of the product is the solidity or capacity, as may be required.

Application of the rules.

1. Required the area in square inches of the slant surface of a cone whose slant height equals $18\frac{3}{4}$ inches, and diameter at the base $6\frac{1}{4}$ inches.

$6{\cdot}25 \times \dot{3}{\cdot}1416 = 19{\cdot}635$, circumference of the base; and

$$\frac{19{\cdot}635 \times 18{\cdot}75}{2} = 184{\cdot}078125 \text{ square inches.}$$

2. Required the quantity of lead, in square feet, sufficient to cover the slant surface of a hexagonal pyramid whose slant height is 42 feet, and the breadth of each side at the base 4 feet 9 inches.

$$\frac{4{\cdot}75 \times 42 \times 6 \text{ sides}}{2} = 598{\cdot}5 \text{ square feet.}$$

. In a square solid pyramid of stone (
;ht, and $16\frac{1}{2}$ feet at the base, how m
?

$$\frac{16{\cdot}5 \times 16{\cdot}5 \times 67}{3} = 6080{\cdot}25 \text{ cubic feet.}$$

'o find the solidity or capacity of any f
me or pyramid.

Rule.—If the base be a circle, add into
two diameters, or, if a regular pol
idth of one side at the top and at the b
n the square of the sum subtract the p
e diameters or breadths; multiply the r
·7854, if a circle, or by the tabular
le of Polygons, p. 36) and by one-thi
;ht, and the product is the content in eq
nity.

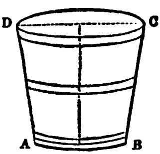
ote.—Where the whole height of the cone c
be obtained, of which the given frustum for
most simple method is first to find the whol
the contents extending beyond the frustum
ing the less from the greater, leaves the cont
um required.

$3{\cdot}75 + 2{\cdot}5 = 6{\cdot}25$, and $6{\cdot}25 \times 6{\cdot}25 = 39{\cdot}0625$; then $3{\cdot}75 \times 2{\cdot}5 = 9{\cdot}375$, and $39{\cdot}0625 - 9{\cdot}375 = 29{\cdot}6875 \times 2{\cdot}598$ (tabular area, p. 36) $= 77{\cdot}138 \times 2{\cdot}5$ or $\frac{1}{3}$ of the height $= 192{\cdot}845$ cubic feet.

2. Required the solidity of the frustum of a cone, the top diameter of which is 7 inches, the base diameter $9\frac{1}{2}$, and the perpendicular height 12.

$(7+9{\cdot}5)^2 = 272{\cdot}25$, and $7 \times 9{\cdot}5 = 66{\cdot}5$; then $272{\cdot}25 - 66{\cdot}5 = 205{\cdot}75 \times {\cdot}7854 = 161{\cdot}576 \times 4$ or $\frac{1}{3}$ of the height $= 646{\cdot}3$ cubic inches.

3. A vessel in the form of an inverted cone, as A B C D, is 5 feet in diameter at the top, 4 feet at the bottom, and 6 feet in depth; required its capacity in imperial gallons.



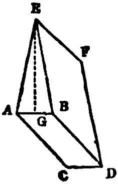
$\overline{5+4} = 9^2 = 81$, and $5 \times 4 = 20$; hence $81 - 20 = 61 \times {\cdot}7854$, and by 2 or $\frac{1}{3}$ of the depth $= 95{\cdot}8188$ cubic feet, and $\times\ 6{\cdot}232 = 597{\cdot}1427$ gallons.

To find the solid contents of a wedge.

Rule.—To twice the length of the base add the length of the edge; multiply the sum by the breadth of the base, and by the perpendicular height from the base, and one-sixth of the product is the solid contents.

Application of the rule.

Required the solidity of a wedge in cubic inches, the base A B C D being 9 inches by $3\frac{1}{2}$, the edge E F, 7 inches, and the perpendicular height G E, 15.



$$\frac{\overline{18+7} \times 3{\cdot}5 \times 15}{6} = 218{\cdot}75 \text{ cubic inches.}$$

ʋ, the product is the solid contents.

ule 3.—Multiply the cube of the diamet 263, or in inches by ·001888, the produ city in imperial gallons.

Application of the rules.

Required the convex surface, the soli weight in cast iron, of a sphere or ball 1(ameter.

× 3·1416=346·3614 square inches.
× ·5236=606·132, &c. cubic inches, and
32 × ·263 (see Table of Approximations, p. 30)=

A hollow or concave copper ball is hes diameter, and in weight just suffi to its centre in common water; wha r thickness of copper of which it ?

it of a cubic inch of water =·03617 lbs. } see
" " copper =·3225 "

$$\frac{236 \times \cdot 03617}{2} = 4\cdot 84828$$ cub. in. of water to be

$$\frac{\cdot 84828}{\cdot 3225} = 15\cdot 0334$$ cubic inches of copper in th

To ascertain the amount of convex surface, also the solid contents, of the segment of a globe.

Rule 1.—Multiply the circumference of the globe or sphere by the height of the segment, and the product is the convex surface.

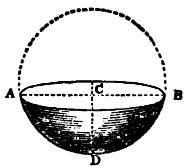
Rule 2.—To three times the square of the segment's radius add the square of its height, multiply the sum by the height, and by ·5236; the product is the solid contents.

Application of the Rules.

1. Required the number of square feet in the convex surface of a sphere, the height of which is $9\frac{1}{2}$ feet, and the circumference of the sphere of which it is a part equal $70\frac{1}{2}$ feet.

$$70{\cdot}5 \times 9{\cdot}5 = 669{\cdot}75 \text{ square feet.}$$

2. The radius A C or B C of the spherical segment A D B equal 48 inches, and the height D C equal 12 inches; required its solidity in cubic inches.



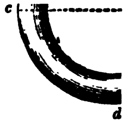
$$48^2 \times 3 = 6912, \text{ and } 12^2 = 144; \text{ then}$$
$$\overline{6912 + 144} \times 12 \times {\cdot}5236 = 44334{\cdot}75 \text{ cubic inches.}$$

To find the convex surface and solidity of a cylindrical ring.

Rule 1.—To the sectional diameter of the ring add the inner diameter of the circle, multiply the sum by the sectional diameter, and by 9·8696; the product is the convex surface.

Rule 2.—To the sectional diameter of the ring add the inner diameter of the circle, multiply the sum by the square of the sectional diameter, and by 2·4674; the product is the solid contents.

required the convex surface and solidity of the ring.



18 feet $\times 12 = 216$ inches, and

$\overline{216+9} \times 9 \times 9{\cdot}8696 = 19985{\cdot}94$ square inches.

$\overline{216+9} \times 9^2 \times 2{\cdot}4674 = 44968{\cdot}365$ cubic inches.

In the formation of a hoop or ring of wr it is found in practice, that in bending tl side or edge which forms the interior diam hoop is upset or shortened, while at the the exterior diameter is drawn or lengthen fore, the proper diameter by which to det length of the iron in an unbent state, is tl from centre to centre of the iron of whic is composed: *hence the rule to determine of the iron.* If it is the interior diameter (that is given, add the thickness of the ii the exterior diameter, subtract from the meter the thickness of the iron, multiply remainder by 3·1416, and the product is of the iron.

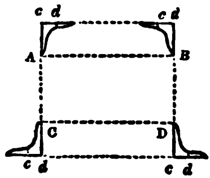
Supposing the interior diameter of a]

ain, let it be required to form a hoop of iron
n in thickness, and 16½ inches outside diameter.

16·5—·875=15·625, or 1 foot 3⅝ inches;

site to which, in the Table of Circumferences,
feet 1 inch, independent of any allowance for
ing.

e length for angle iron, of which to form a ring
given diameter, varies according to the strength
e iron at the root; and the rule is, for a ring
the flange outside, *add* to its required interior
eter, twice the extreme strength of the iron at
oot; or, for a ring with the flange inside, *sub-*
twice the extreme strength; and the sum or
inder is the diameter by which to determine the
h of the angle iron. Thus,
ose two angle iron rings
ar to the following be re-
d, the exterior diameter A
nd interior diameter C D,
to be 1 foot 10½ inches,
he extreme length of the
at the root *c d*, *c d*, &c. ⅞
inch.



⅞=1¾, and 1 ft. 10½ in. + 1¾=2 ft. ¼ in., opposite to which,
he Table of Circumferences, is 6 ft. 4¼ in., the length of
iron for C D; and 1 ft. 10½ in.—1¾=1 ft. 8¾ in., opposite
which is 5 ft. 5¼ in., the length of the iron for A B.

observe as before, that the necessary allowance
cutting must be added to the length of the iron,
dition to the length as expressed by the Table.

owing, with reference to 
he annexed plan.

,ength, or dist. between	A and B	= 10 ft.	$2\frac{3}{4}$ in. or		
3readth „	C „ D	= 6 „	$7\frac{1}{2}$ „		
,ength „	i „ g	= 3 „	$10\frac{3}{4}$ „		
Mean breadth of coke space or	lm „	= 3 „	$1\frac{1}{4}$ „		
)iameter of circle	rn „	= 2 „	$8\frac{1}{4}$ „		
„ „	ps „	= 1 „	$6\frac{1}{2}$ „		
ladius of back corners	vx „	=	4 „		

Then, $122{\cdot}75 \times 79{\cdot}5 = 9758{\cdot}525$ square inches, as
And $18{\cdot}5^2 \times {\cdot}7854 = 268{\cdot}8$ „ „ are
'ormed by the two ends.

Total $\overline{10027{\cdot}325}$ „ „ fro
leduct the area of the coke space, and the differe
›etween the semicircle formed by the two back c
hat of a rectangle of equal length and breadth;

Then $46{\cdot}75 \times 37{\cdot}25 = 1731{\cdot}4375$ area of r, n, s, t,

$\frac{32{\cdot}25^2 \times {\cdot}7854}{2} = 408{\cdot}4$ area of half the

Radius of back corners = 4 inches;
consequently $8^2 \times {\cdot}7854 = 25{\cdot}13$, the semicir
and $8 \times 4 = 32 - 25{\cdot}13 = 6{\cdot}87$ inches taken off b
the corners.

Hence, $1731{\cdot}4375 + 408{\cdot}4 + 6{\cdot}87 = 2146{\cdot}707$, a

standard of comparison, or 1000.

Names.	Specific gravity.	METALS.							
		Melting points in degrees of Fahrenheit.	Contraction in parts of an in. per lineal ft. from the fluid to the average temperature in solid state.	Ultimate cohesive strength of an inch sq. prism in tons.	Scale of wire-drawing ductility.	Scale of laminable ductility.	Ratio of hardness.	Scale as conductors of electricity.	Ratio of power in the conduction of heat.
Platinum	19500	3280	—	—	3	5	—	—	3·8
Pure Gold . . .	19258	2016	—	—	1	1	1·8	3	10·0
Mercury	13500	—	—	—	—	—	—	—	—
Lead	11352	612	·319	·81	8	7	1·0	6	1·8
Pure Silver . . .	10474	1873	—	—	2	2	2·4	2	9·7
Bismuth	9823	476	·156	1·45	—	—	2·0	—	—
Copper, cast . .	8788	1996	·193	8·51	—	—	—	—	—
„ wrought	8910	—	—	15·08	5	3	2·8	1	8·9
Brass, cast . . .	7824	1900	·210	8·01	—	—	to any degree	—	—
„ sheet . .	8396	—	—	12·23	6	6	—	—	8·6
Iron, cast	7264	2786	·125	7·87	—	—	to any degree	—	—
„ bar	7700	—	·137	25·00	4	8	4·7	4	3·7
Steel, soft . . .	7833	—	·133	53·91	—	—	—	—	—
„ hard . . .	7816	—	—	—	—	—	to any degree	—	—
Tin, cast	7291	442	·278	2·11	8	4	1·2	5	3·0
Zinc, cast . . .	7190	773	·329	5·06	7	8	1·6	7	3·6

Names.	STONES, EARTHS, &c.			
	Specific gravity.	Weight of a cubic foot in lbs.	Cubic feet in a ton.	Tons required to crush $1\frac{1}{2}$-inch cubes.
Marble, average	2720	170·00	13	9·25
Granite, do. . .	2651	165·68	$13\frac{1}{2}$	6·2
Purbeck stone .	2601	162·56	$13\frac{3}{4}$	9·0
Portland do. . .	2570	160·62	14	4·5
Bristol do. . . .	2554	159·62	14	—
Millstone. . . .	2484	155·25	$14\frac{1}{2}$	—
Paving stone . .	2415	150·93	$14\frac{3}{4}$	5·7
Craigleith do. .	2362	147·62	15	5·0
Grindstone. . .	2143	133·93	$16\frac{3}{4}$	6·6
Chalk, Brit. . .	2781	173·81	$12\frac{3}{4}$	0·5
Brick	2000	125·00	17	0·8
Coal, Scotch . .	1300	81·15	$27\frac{1}{2}$	—
„ Newcastle	1270	79·37	$27\frac{1}{4}$	—
„ Staffordsh.	1240	77·50	29	—
„ Cannel . .	1238	77·37	29	—

Names.	Specific water, 10	Average cubic foo	Cubic fe a ton.	Ultimate sive stre an inch prism in	Stiffness
English oak	934	58	38½	11880	100
Riga do.	872	54	41½	12888	93
Dantzic do.......	756	47	48	12780	117
American do.....	672	42	53	10253	114
Beech..........	852	48	45	12225	77
Alder	800	46	48½	9540	63
Plane	640	40	55	10935	78
Sycamore	604	38	59	9630	59
Chestnut........	610	38	59	10656	67
Ash............	845	52	43	14130	89
Elm............	673	42	53	9720	78
Mahog. Spanish ..	800	50	45	7560	73
„ Honduras	637	40	55	11475	93
Walnut.........	671	42	53	8800	49
Teak...........	750	46	48½	12915	126
Poona..........	640	40	55	12350	99
African oak......	944	59	38	17200	101
Poplar..........	383	34	66	5928	44
Cedar	561	33	68	7420	28
Riga fir.........	753	47	48	9540	98
Memel do.	546	34	66	9540	114
Scotch do.	528	33	68	7110	55
Christ. whte. deal .	590	37	60	12346	104

LIQUIDS.

Names.	Specific grav., water, 1000.	Weight of an imperial gall. in lbs.
Acid, sulphuric ..	1850	18·5
„ nitric	1271	12·7
„ muriatic ...	1200	12·0
„ fluoric.....	1060	10·6
„ citric......	1034	10·3
„ acetic	1062	10·6
Water from the Baltic	1015	10·2
Water from the Dead Sea	1240	12·4
Water from the Mediterranean .	1029	10·3
Water, distilled ..	1000	10·0
Oils, expressed:		
„ linseed.....	940	9·4
„ sweet almond	932	9·3
„ whale......	923	9·2
„ hempseed...	926	9·3
„ olive.......	915	9·2
Oils, essential:		
„ cinnamon...	1043	10·4
„ lavender....	894	8·9
„ turpentine ..	870	8·7
„ amber......	868	8·7
Alcohol	825	8·2
Ether, nitric	908	9·1
Proof spirit......	922	9·2
Vinegar	1009	10·1

GASES.

Atmospheric air being the standard of comparison, or 1000.

Names.	Specific gravity.
Hydriodic acid gas	4340
Chlorine acid „	2500
Carbonic acid „	1527
Nitrous oxide „	1527
Cyanogen „	1805
Oxygen „	1111
Carbonic oxide „	972
Carburetted hydrogen gas	972
Prussic acid „	937
Ammoniacal do. „	590
Steam of water „	623
Hydrogen „	69

Weight of water at the common temperature:

1 cubic inch = ·03617 lb.
1 „ foot = 62·5 „
1 „ „ = 6·25 imp. galls.
1·8 „ „ = 1 cwt.
1 cylindrical inch = ·02842 lb.
1 „ foot = 49·1 „
1 „ „ = 5 imp. galls.
2·282 feet = 1 cwt.
11·2 imp. gallons = 1 cwt.
224 „ „ = 1 ton.

[illegible]	[illegible]	[illegible]	lbs.	[illegible]	lbs.
$\frac{1}{4}$	·208	2	13·33	$\frac{1}{4}$	·163
$\frac{5}{16}$	·325	$2\frac{1}{8}$	15·05	$\frac{5}{16}$	·255
$\frac{3}{8}$	·468	$2\frac{1}{4}$	16·87	$\frac{3}{8}$	·368
$\frac{7}{16}$	·638	$2\frac{3}{8}$	18·80	$\frac{7}{16}$	·501
$\frac{1}{2}$	·833	$2\frac{1}{2}$	20·81	$\frac{1}{2}$	·654
$\frac{9}{16}$	1·05	$2\frac{5}{8}$	22·96	$\frac{9}{16}$	·828
$\frac{5}{8}$	1·30	$2\frac{3}{4}$	25·20	$\frac{5}{8}$	1·02
$\frac{11}{16}$	1·57	$2\frac{7}{8}$	27·55	$\frac{11}{16}$	1·23
$\frac{3}{4}$	1·87	3	30·00	$\frac{3}{4}$	1·47
$\frac{13}{16}$	2·20	$3\frac{1}{8}$	32·55	$\frac{13}{16}$	1·72
$\frac{7}{8}$	2·55	$3\frac{1}{4}$	35·20	$\frac{7}{8}$	2·00
$\frac{15}{16}$	2·92	$3\frac{3}{8}$	37·96	$\frac{15}{16}$	2·30
1	3·33	$3\frac{1}{2}$	40·80	1	2·61
$1\frac{1}{16}$	3·76	$3\frac{5}{8}$	43·81	$1\frac{1}{16}$	2·95
$1\frac{1}{8}$	4·21	$3\frac{3}{4}$	46·87	$1\frac{1}{8}$	3·31
$1\frac{3}{16}$	4·70	$3\frac{7}{8}$	50·05	$1\frac{3}{16}$	3·69
$1\frac{1}{4}$	5·20	4	53·33	$1\frac{1}{4}$	4·09
$1\frac{5}{16}$	5·74	$4\frac{1}{4}$	60·20	$1\frac{5}{16}$	4·51
$1\frac{3}{8}$	6·30	$4\frac{1}{2}$	67·50	$1\frac{3}{8}$	4·95
$1\frac{7}{16}$	6·88	$4\frac{3}{4}$	75·20	$1\frac{7}{16}$	5·40
$1\frac{1}{2}$	7·50	5	83·33	$1\frac{1}{2}$	5·89
$1\frac{9}{16}$	8·15	$5\frac{1}{4}$	92·43	$1\frac{9}{16}$	6·40
$1\frac{5}{8}$	8·80	$5\frac{1}{2}$	101·03	$1\frac{5}{8}$	6·91
$1\frac{11}{16}$	9·50	$5\frac{3}{4}$	110·40	$1\frac{11}{16}$	7·46
$1\frac{3}{4}$	10·20	6	120·21	$1\frac{3}{4}$	8·01
$1\frac{13}{16}$	10·69	$6\frac{1}{4}$	130·20	$1\frac{13}{16}$	[illegible]

WEIGHT OF A LINEAL FOOT OF FLAT BAR IRON IN POUNDS.

Breadth in inches.	Thickness in parts of an inch.						
	1/4	5/16	3/8	7/16	1/2	9/16	5/8
1/2	·417	·52	—	—	—	—	—
5/8	·52	·65	·78	·91	—	—	—
3/4	·625	·785	·93	1·09	1·25	1·40	—
7/8	·725	·91	1·09	1·27	1·46	1·64	1·82
1	·834	1·04	1·25	1·45	1·67	1·87	2·08
1 1/8	·937	1·17	1·40	1·64	1·87	2·10	2·34
1 1/4	1·04	1·30	1·56	1·82	2·08	2·34	2·60
1 3/8	1·14	1·43	1·71	2·00	2·29	2·57	2·86
1 1/2	1·25	1·56	1·87	2·18	2·50	2·81	3·12
1 5/8	1·35	1·69	2·03	2·36	2·70	3·04	3·38
1 3/4	1·45	1·82	2·18	2·55	2·91	3·28	3·64
1 7/8	1·56	1·95	2·34	2·73	3·12	3·51	3·90
2	1·66	2·08	2·50	2·91	3·33	3·75	4·16
2 1/8	1·77	2·21	2·65	3·09	3·54	3·98	4·42
2 1/4	1·87	2·34	2·81	3·28	3·75	4·21	4·68
2 3/8	1·97	2·47	2·96	3·46	3·95	4·45	4·94
2 1/2	2·08	2·60	3·12	3·64	4·16	4·68	5·20
2 5/8	2·18	2·73	3·28	3·82	4·37	4·92	5·46
2 3/4	2·29	2·86	3·43	4·01	4·58	5·15	5·72
2 7/8	2·39	2·99	3·59	4·19	4·79	5·39	5·98
3	2·50	3·12	3·75	4·37	5·00	5·62	6·25
3 1/4	2·70	3·38	4·06	4·73	5·41	6·09	6·77
3 1/2	2·91	3·64	4·37	5·10	5·83	6·56	7·29
3 3/4	3·12	3·90	4·68	5·46	6·25	7·03	7·81
4	3·33	4·16	5·00	5·83	6·66	7·50	8·33
4 1/4	3·54	4·42	5·31	6·19	7·08	7·96	8·85
4 1/2	3·75	4·68	5·62	6·56	7·50	8·43	9·37
4 3/4	3·95	4·94	5·93	6·92	7·91	8·90	9·89
5	4·17	5·20	6·25	7·29	8·33	9·37	10·41
5 1/4	4·37	5·46	6·56	7·65	8·75	9·84	10·93
5 1/2	4·58	5·72	6·87	8·02	9·16	10·31	11·45
5 3/4	4·79	5·98	7·18	8·38	9·58	10·78	11·97
6	5·	6·26	7·50	8·75	10·00	11·25	12·50

1⅛	2·57	2·81	3·04	—	—	—
1¼	2·86	3·12	3·38	3·64	3·90	—
1⅜	3·15	3·43	3·72	4·01	4·29	4·
1½	3·43	3·75	4·06	4·37	4·68	5·
1⅝	3·72	4·06	4·40	4·73	5·07	5·
1¾	4·01	4·37	4·73	5·10	5·46	5·
1⅞	4·29	4·68	5·07	5·46	5·85	6·
2	4·58	5·00	5·41	5·83	6·25	6·
2⅛	4·86	5·31	5·75	6·19	6·64	7·
2¼	5·15	5·62	6·09	6·56	7·03	7·
2⅜	5·44	5·93	6·43	6·92	7·42	7·
2½	5·72	6·25	6·77	7·29	7·81	8·
2⅝	6·01	6·56	7·10	7·65	8·20	8·
2¾	6·30	6·87	7·44	8·02	8·59	9·
2⅞	6·58	7·18	7·78	8·38	8·98	9·
3	6·87	7·50	8·12	8·75	9·37	10·
3¼	7·44	8·12	8·80	9·47	10·15	10·
3½	8·02	8·75	9·47	10·20	10·93	11·
3¾	8·59	9·37	10·15	10·93	11·71	12·
4	9·16	10·00	10·83	11·66	12·50	13·
4¼	9·73	10·62	11·51	12·39	13·28	14·
4½	10·31	11·25	12·18	13·12	14·06	15·
4¾	10·88	11·87	12·86	13·85	14·84	15·
5	11·45	12·50	13·54	14·58	15·62	16·

WEIGHT OF FLAT BAR IRON—*continued.*

Breadth in inches.	Thickness in inches.					
	1¼	1⅜	1½	1¾	2	2½
1½	6·24	6·86	—	—	—	—
1¾	7·28	8·02	8·74	—	—	—
2	8·32	9·16	10·00	11·66	—	—
2¼	9·36	10·30	11·24	13·12	15·00	—
2½	10·40	11·44	12·50	14·58	16·66	—
2¾	11·44	12·60	13·74	16·04	18·32	22·88
3	12·50	13·74	15·00	17·50	20·00	25·00
3¼	13·54	14·88	16·24	18·94	21·66	27·08
3½	14·58	16·04	17·50	20·40	23·32	29·16
3¾	15·62	17·18	18·74	21·86	25·00	31·24
4	16·66	18·32	20·00	23·32	26·66	33·32
4¼	17·70	19·46	21·24	25·78	28·32	35·40
4½	18·74	20·62	22·50	26·24	30·00	37·48
4¾	19·78	21·76	23·74	27·70	31·67	39·56
5	20·82	22·90	25·00	29·16	33·32	41·64
5¼	21·86	24·06	26·24	30·62	35·00	43·72
5½	22·90	25·20	27·50	32·08	36·66	45·80
5¾	23·94	26·34	28·74	33·54	38·32	47·88
6	25·00	27·50	30·00	35·00	40·00	50·00
6½	27·08	29·76	32·48	37·88	43·32	54·16
7	29·16	32·08	35·00	40·80	46·64	58·32
7½	31·24	34·36	37·48	43·72	50·00	62·48
8	33·32	36·64	40·00	46·64	53·32	66·64
8½	35·40	38·92	42·48	51·56	56·64	70·80
9	37·48	41·24	45·00	52·48	60·00	74·96

MECHANICAL TABLES

FOR THE USE OF OPERATIVE SMITHS, MILLWRIGHTS, AND ENGINEERS.

The following Tables, originally dedicated to 'the National Association of the Forgers of Iron-Work,' are, with permission, added to the present edition: they will be found extremely useful to Smiths generally, and are accompanied by Observations and Practical Examples.

0	$3\frac{1}{8}$	$5\frac{1}{8}$	1	4	0	$9\frac{1}{8}$	2	$4\frac{5}{8}$
0	$3\frac{7}{8}$	$5\frac{1}{4}$	1	$4\frac{3}{8}$	0	$9\frac{1}{4}$	2	5
0	$4\frac{1}{4}$	$5\frac{3}{8}$	1	$4\frac{7}{8}$	0	$9\frac{3}{8}$	2	$5\frac{3}{8}$
0	$4\frac{5}{8}$	$5\frac{1}{2}$	1	$5\frac{1}{4}$	0	$9\frac{1}{2}$	2	$5\frac{3}{4}$
0	5	$5\frac{5}{8}$	1	$5\frac{5}{8}$	0	$9\frac{5}{8}$	2	$6\frac{1}{8}$
0	$5\frac{3}{8}$	$5\frac{3}{4}$	1	6	0	$9\frac{3}{4}$	2	$6\frac{5}{8}$
0	$5\frac{7}{8}$	$5\frac{7}{8}$	1	$6\frac{3}{8}$	0	$9\frac{7}{8}$	2	7
0	$6\frac{1}{4}$	6	1	$6\frac{3}{4}$	0	10	2	$7\frac{3}{8}$
0	$6\frac{5}{8}$	$6\frac{1}{8}$	1	$7\frac{1}{8}$	0	$10\frac{1}{8}$	2	$7\frac{3}{4}$
0	7	$6\frac{1}{4}$	1	$7\frac{5}{8}$	0	$10\frac{1}{4}$	2	$8\frac{1}{8}$
0	$7\frac{3}{8}$	$6\frac{3}{8}$	1	8	0	$10\frac{3}{8}$	2	$8\frac{1}{2}$
0	$7\frac{3}{4}$	$6\frac{1}{2}$	1	$8\frac{3}{8}$	0	$10\frac{1}{2}$	2	$8\frac{7}{8}$
0	$8\frac{1}{8}$	$6\frac{5}{8}$	1	$8\frac{3}{4}$	0	$10\frac{5}{8}$	2	$9\frac{3}{8}$
0	$8\frac{5}{8}$	$6\frac{3}{4}$	1	$9\frac{1}{8}$	0	$10\frac{3}{4}$	2	$9\frac{3}{4}$
0	9	$6\frac{7}{8}$	1	$9\frac{1}{2}$	0	$10\frac{7}{8}$	2	$10\frac{1}{8}$
0	$9\frac{3}{8}$	7	1	$9\frac{7}{8}$	0	11	2	$10\frac{1}{2}$
0	$9\frac{3}{4}$	$7\frac{1}{8}$	1	$10\frac{3}{8}$	0	$11\frac{1}{8}$	2	$10\frac{7}{8}$
0	$10\frac{1}{8}$	$7\frac{1}{4}$	1	$10\frac{3}{4}$	0	$11\frac{1}{4}$	2	$11\frac{1}{4}$
0	$10\frac{1}{2}$	$7\frac{3}{8}$	1	$11\frac{1}{8}$	0	$11\frac{3}{8}$	2	$11\frac{5}{8}$
0	$10\frac{7}{8}$	$7\frac{1}{2}$	1	$11\frac{1}{2}$	0	$11\frac{1}{2}$	3	0
0	$11\frac{3}{8}$	$7\frac{5}{8}$	1	$11\frac{7}{8}$	0	$11\frac{5}{8}$	3	$0\frac{1}{2}$
0	$11\frac{3}{4}$	$7\frac{3}{4}$	2	$0\frac{1}{4}$	0	$11\frac{3}{4}$	3	$0\frac{7}{8}$
1	$0\frac{1}{8}$	$7\frac{7}{8}$	2	$0\frac{5}{8}$	0	$11\frac{7}{8}$	3	$1\frac{1}{4}$
1	$0\frac{1}{2}$	8	2	$1\frac{1}{8}$	1	0	3	$1\frac{5}{8}$

Diam.		Circum.		Diam.		Circum.		Diam.		Circum.		Diam.		Circum.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
1	5	4	5⅜	1	9⅜	5	7⅛	2	1¾	6	8⅞	2	6⅛	7	10⅝
1	5⅛	4	5¾	1	9½	5	7½	2	1⅞	6	9¼	2	6¼	7	11
1	5¼	4	6⅛	1	9⅝	5	8	2	2	6	9⅝	2	6⅜	7	11⅜
1	5⅜	4	6½	1	9¾	5	8⅜	2	2⅛	6	10	2	.6½	7	11¾
1	5½	4	6⅞	1	9⅞	5	8¾	2	2¼	6	10⅜	2	6⅝	8	0⅛
1	5⅝	4	7⅜	1	10	5	9	2	2⅜	6	10¾	2	6¾	8	0½
1	5¾	4	7¾	1	10⅛	5	9½	2	2½	6	11¼	2	6⅞	8	0⅞
1	5⅞	4	8⅛	1	10¼	5	9⅞	2	2⅝	6	11⅝	2	7	8	1⅜
1	6	4	8½	1	10⅜	5	10¼	2	2¾	7	0	2	7⅛	8	1¾
1	6⅛	4	8⅞	1	10½	5	10⅝	2	2⅞	7	0⅜	2	7¼	8	2⅛
1	6¼	4	9¼	1	10⅝	5	11	2	3	7	0¾	2	7⅜	8	2½
1	6⅜	4	9⅝	1	10¾	5	11⅜	2	3⅛	7	1⅛	2	7½	8	2⅞
1	6½	4	10	1	10⅞	5	11¾	2	3¼	7	1½	2	7⅝	8	3¼
1	6⅝	4	10⅜	1	11	6	0¼	2	3⅜	7	2	2	7¾	8	3¾
1	6¾	4	10⅞	1	11⅛	6	0⅝	2	3½	7	2⅜	2	7⅞	8	4⅛
1	6⅞	4	11¼	1	11¼	6	1	2	3⅝	7	2¾	2	8	8	4½
1	7	4	11⅝	1	11⅜	6	1⅜	2	3¾	7	3⅛	2	8⅛	8	4⅞
1	7⅛	5	0	1	11½	6	1¾	2	3⅞	7	3½	2	8¼	8	5¼
1	7¼	5	0⅜	1	11⅝	6	2⅛	2	4	7	3⅞	2	8⅜	8	5⅝
1	7⅜	5	0⅞	1	11¾	6	2½	2	4⅛	7	4¼	2	8½	8	6
1	7½	5	1¼	1	11⅞	6	3	2	4¼	7	4¾	2	8⅝	8	6½
1	7⅝	5	1⅝	2	0	6	3⅜	2	4⅜	7	5⅛	2	8¾	8	6⅞
1	7¾	5	2	2	0⅛	6	3¾	2	4½	7	5½	2	8⅞	8	7¼
1	7⅞	5	2⅜	2	0¼	6	4⅛	2	4⅝	7	5⅞	2	9	8	7⅝
1	8	5	2¾	2	0⅜	6	4½	2	4¾	7	6¼	2	9⅛	8	8
1	8⅛	5	3⅛	2	0½	6	4⅞	2	4⅞	7	6⅝	2	9¼	8	8⅜
1	8¼	5	3⅝	2	0⅝	6	5¼	2	5	7	7	2	9⅜	8	8¾
1	8⅜	5	4	2	0¾	6	5¾	2	5⅛	7	7½	2	9½	8	9¼
1	8½	5	4⅜	2	0⅞	6	6⅛	2	5¼	7	7⅞	2	9⅝	8	9⅝
1	8⅝	5	4¾	2	1	6	6½	2	5⅜	7	8¼	2	9¾	8	10
1	8¾	5	5⅛	2	1⅛	6	6⅞	2	5½	7	8⅝	2	9⅞	8	10⅜
1	8⅞	5	5½	2	1¼	6	7¼	2	5⅝	7	9	2	10	8	10¾
1	9	5	5⅞	2	1⅜	6	7⅝	2	5¾	7	9⅜	2	10⅛	8	11⅛
1	9⅛	5	6⅜	2	1½	6	8	2	5⅞	7	9¾	2	10¼	8	11½
1	9¼	5	6¾	2	1⅝	6	8½	2	6	7	10⅛	2	10⅜	8	11⅞

		3	3⅜	10	3⅝	3	7¾	11	5⅜	
9	2¼	3	3½	10	4	3	7⅞	11	5¾	4
9	2⅝	3	3⅝	10	4½	3	8	11	6⅛	4
9	3	3	3¾	10	4⅞					4
9	3⅜	3	3⅞	10	5¼	3	8⅛	11	6½	4
9	3⅞	3	4	10	5⅝	3	8¼	11	7	4
9	4¼					3	8⅜	11	7⅜	4
9	4⅝	3	4⅛	10	6	3	8½	11	7¾	4
9	5	3	4¼	10	6⅜	3	8⅝	11	8⅛	4
		3	4⅜	10	6¾	3	8¾	11	8½	
9	5⅜	3	4½	10	7⅛	3	8⅞	11	8⅞	4
9	5⅞	3	4⅝	10	7⅝	3	9	11	9¼	4
9	6¼	3	4¾	10	8					4
9	6⅝	3	4⅞	10	8⅜	3	9⅛	11	9¾	4
9	7	3	5	10	8¾	3	9¼	11	10⅛	4
9	7⅜					3	9⅜	11	10½	4
9	7¾					3	9½	11	10⅞	4
9	8⅛	3	5⅛	10	9⅛	3	9⅝	11	11¼	4
		3	5¼	10	9½	3	9¾	11	11⅝	
9	8⅝	3	5⅜	10	9⅞	3	9⅞	12	0	4
9	9	3	5½	10	10⅜	3	10	12	0½	4
9	9⅜	3	5⅝	10	10¾					4
9	9¾	3	5¾	10	11⅛	3	10⅛	12	0⅞	4
9	10⅛	3	5⅞	10	11½	3	10¼	12	1¼	4
9	10½	3	6	10	11⅞	3	10⅜	12	1⅝	4
9	10⅞					3	10½	12	2	4
9	11⅜	3	6⅛	11	0¼	3	10⅝	12	2⅜	4

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
4	3⅞	13	6⅞
4	4	13	7¼
4	4⅛	13	7¾
4	4¼	13	8⅛
4	4⅜	13	8½
4	4½	13	8⅞
4	4⅝	13	9¼
4	4¾	13	9⅝
4	4⅞	13	10
4	5	13	10½
4	5⅛	13	10⅞
4	5¼	13	11¼
4	5⅜	13	11⅝
4	5½	14	0
4	5⅝	14	0⅜
4	5¾	14	0⅞
4	5⅞	14	1¼
4	6	14	1⅝
4	6⅛	14	2
4	6¼	14	2⅜
4	6⅜	14	2¾
4	6½	14	3⅛
4	6⅝	14	3½
4	6¾	14	4
4	6⅞	14	4⅜
4	7	14	4¾
4	7⅛	14	5⅛
4	7¼	14	5½
4	7⅜	14	5⅞
4	7½	14	6¼
4	7⅝	14	6¾
4	7¾	14	7⅛
4	7⅞	14	7½
4	8	14	7⅞

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
4	8⅛	14	8¼
4	8¼	14	8⅝
4	8⅜	14	9
4	8½	14	9½
4	8⅝	14	9⅞
4	8¾	14	10¼
4	8⅞	14	10⅝
4	9	14	11
4	9⅛	14	11⅜
4	9¼	14	11¾
4	9⅜	15	0⅛
4	9½	15	0⅝
4	9⅝	15	1
4	9¾	15	1⅜
4	9⅞	15	1¾
4	10	15	2⅛
4	10⅛	15	2½
4	10¼	15	2⅞
4	10⅜	15	3⅜
4	10½	15	3¾
4	10⅝	15	4⅛
4	10¾	15	4½
4	10⅞	15	4⅞
4	11	15	5¼
4	11⅛	15	5⅝
4	11¼	15	6⅛
4	11⅜	15	6½
4	11½	15	6⅞
4	11⅝	15	7¼
4	11¾	15	7⅝
4	11⅞	15	8
5	0	15	8⅜
5	0⅛	15	8⅞
5	0¼	15	9¼
5	0⅜	15	9⅝

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
5	0½	15	10
5	0⅝	15	10⅜
5	0¾	15	10¾
5	0⅞	15	11⅛
5	1	15	11⅝
5	1⅛	16	0
5	1¼	16	0⅜
5	1⅜	16	0¾
5	1½	16	1⅛
5	1⅝	16	1½
5	1¾	16	1⅞
5	1⅞	16	2⅜
5	2	16	2¾
5	2⅛	16	3⅛
5	2¼	16	3½
5	2⅜	16	3⅞
5	2½	16	4¼
5	2⅝	16	4⅝
5	2¾	16	5⅛
5	2⅞	16	5½
5	3	16	5⅞
5	3⅛	16	6¼
5	3¼	16	6⅝
5	3⅜	16	7
5	3½	16	7⅜
5	3⅝	16	7⅞
5	3¾	16	8¼
5	3⅞	16	8⅝
5	4	16	9
5	4⅛	16	9⅝
5	4¼	16	9¾
5	4⅜	16	10⅛
5	4½	16	10⅝
5	4⅝	16	11
5	4¾	16	11⅜

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
5	4⅞	16	11¾
5	5	17	0⅛
5	5⅛	17	0⅝
5	5¼	17	1
5	5⅜	17	1⅜
5	5½	17	1¾
5	5⅝	17	2⅛
5	5¾	17	2½
5	5⅞	17	2⅞
5	6	17	3¼
5	6⅛	17	3⅝
5	6¼	17	4⅛
5	6⅜	17	4½
5	6½	17	4⅞
5	6⅝	17	5¼
5	6¾	17	5⅝
5	6⅞	17	6
5	7	17	6⅜
5	7⅛	17	6⅞
5	7¼	17	7¼
5	7⅜	17	7⅝
5	7½	17	8
5	7⅝	17	8⅜
5	7¾	17	8¾
5	7⅞	17	9⅛
5	8	17	9⅝
5	8⅛	17	10
5	8¼	17	10⅜
5	8⅜	17	10¾
5	8½	17	11⅛
5	8⅝	17	11½
5	8¾	17	11⅞
5	8⅞	18	0⅜
5	9	18	0¾

9⅝	18	2⅝
9¾	18	3
9⅞	18	3½
10	18	3⅞
10⅛	18	4¼
10¼	18	4⅝
10⅜	18	5
10½	18	5⅜
10⅝	18	5⅞
10¾	18	6¼
10⅞	18	6⅝
11	18	7
11⅛	18	7⅜
11¼	18	7¾
11⅜	18	8⅛
11½	18	8½
11⅝	18	9
11¾	18	9⅜
11⅞	18	9¾
0	18	10⅛
0⅛	18	10½
0¼	18	10⅞
0⅜	18	11¼

6	2	19	4⅜
6	2⅛	19	4¾
6	2¼	19	5¼
6	2⅜	19	5⅝
6	2½	19	6
6	2⅝	19	6⅜
6	2¾	19	6¾
6	2⅞	19	7⅛
6	3	19	7½
6	3⅛	19	8
6	3¼	19	8⅜
6	3⅜	19	8¾
6	3½	19	9⅛
6	3⅝	19	9½
6	3¾	19	9⅞
6	3⅞	19	10¼
6	4	19	10¾
6	4⅛	19	11⅛
6	4¼	19	11½
6	4⅜	19	11⅞
6	4½	20	0¼
6	4⅝	20	0⅝
6	4¾	20	1

6	6¼	20	5¾
6	6⅜	20	6⅛
6	6½	20	6½
6	6⅝	20	7
6	6¾	20	7⅜
6	6⅞	20	7¾
6	7	20	8⅛
6	7⅛	20	8½
6	7¼	20	8⅞
6	7⅜	20	9¼
6	7½	20	9¾
6	7⅝	20	10⅛
6	7¾	20	10½
6	7⅞	20	10⅞
6	8	20	11¼
6	8⅛	20	11⅝
6	8¼	21	0
6	8⅜	21	0½
6	8½	21	0⅞
6	8⅝	21	1¼
6	8¾	21	1⅝
6	8⅞	21	2
6	9	21	2⅜

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
7	2½	22	7⅝
7	2⅝	22	8⅛
7	2¾	22	8½
7	2⅞	22	8⅞
7	3	22	9¼
7	3⅛	22	9⅝
7	3¼	22	10
7	3⅜	22	10⅜
7	3½	22	10⅞
7	3⅝	22	11¼
7	3¾	22	11⅝
7	3⅞	23	0
7	4	23	0⅜
7	4⅛	23	0¾
7	4¼	23	1⅛
7	4⅜	23	1⅝
7	4½	23	2
7	4⅝	23	2⅜
7	4¾	23	2¾
7	4⅞	23	3⅛
7	5	23	3½
7	5⅛	23	3⅞
7	5¼	23	4⅜
7	5⅜	23	4¾
7	5½	23	5⅛
7	5⅝	23	5½
7	5¾	23	5⅞
7	5⅞	23	6¼
7	6	23	6⅝
7	6⅛	23	7⅛
7	6¼	23	7½
7	6⅜	23	7⅞
7	6½	23	8¼
7	6⅝	23	8⅝
7	6¾	23	9

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
7	6⅞	23	9⅜
7	7	23	9⅞
7	7⅛	23	10¼
7	7¼	23	10⅝
7	7⅜	23	11
7	7½	23	11⅜
7	7⅝	23	11¾
7	7¾	24	0⅛
7	7⅞	24	0⅝
7	8	24	1
7	8⅛	24	1⅜
7	8¼	24	1¾
7	8⅜	24	2⅛
7	8½	24	2½
7	8⅝	24	2⅞
7	8¾	24	3⅜
7	8⅞	24	3¾
7	9	24	4⅛
7	9⅛	24	4½
7	9¼	24	4⅞
7	9⅜	24	5¼
7	9½	24	5⅝
7	9⅝	24	6⅛
7	9¾	24	6½
7	9⅞	24	6⅞
7	10	24	7¼
7	10⅛	24	7⅝
7	10¼	24	8
7	10⅜	24	8⅜
7	10½	24	8⅞
7	10⅝	24	9¼
7	10¾	24	9⅝
7	10⅞	24	10
7	11	24	10⅜

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
7	11⅛	24	10¾
7	11¼	24	11⅛
7	11⅜	24	11½
7	11½	25	0
7	11⅝	25	0⅜
7	11¾	25	0¾
7	11⅞	25	1⅛
8	0	25	1½
8	0⅛	25	1⅞
8	0¼	25	2⅜
8	0⅜	25	2¾
8	0½	25	3⅛
8	0⅝	25	3½
8	0¾	25	3⅞
8	0⅞	25	4¼
8	1	25	4⅝
8	1⅛	25	5⅛
8	1¼	25	5½
8	1⅜	25	5⅞
8	1½	25	6¼
8	1⅝	25	6⅝
8	1¾	25	7
8	1⅞	25	7⅜
8	2	25	7⅞
8	2⅛	25	8¼
8	2¼	25	8⅝
8	2⅜	25	9
8	2½	25	9⅜
8	2⅝	25	9¾
8	2¾	25	10⅛
8	2⅞	25	10½
8	3	25	11
8	3⅛	25	11⅜
8	3¼	25	11¾
8	3⅜	26	0⅛

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
8	3½	26	0
8	3⅝	26	0
8	3¾	26	1
8	3⅞	26	1
8	4	26	2
8	4⅛	26	2
8	4¼	26	2
8	4⅜	26	3
8	4½	26	3
8	4⅝	26	4
8	4¾	26	4
8	4⅞	26	4
8	5	26	5
8	5⅛	26	5
8	5¼	26	6
8	5⅜	26	6
8	5½	26	6
8	5⅝	26	7
8	5¾	26	7
8	5⅞	26	8
8	6	26	8
8	6⅛	26	8
8	6¼	26	9
8	6⅜	26	9
8	6½	26	10
8	6⅝	26	10
8	6¾	26	10
8	6⅞	26	11
8	7	26	11
8	7⅛	26	11
8	7¼	27	0
8	7⅜	27	0
8	7½	27	1
8	7⅝	27	1
8	7¾	27	1

27	$3\frac{1}{2}$
27	$3\frac{7}{8}$
27	$4\frac{1}{4}$
27	$4\frac{5}{8}$
27	5
27	$5\frac{3}{8}$
27	$5\frac{3}{4}$
27	$6\frac{1}{4}$
27	$6\frac{5}{8}$
27	7
27	$7\frac{3}{8}$
27	$7\frac{3}{4}$
27	$8\frac{1}{8}$
27	$8\frac{1}{2}$
27	9
27	$9\frac{3}{8}$
27	$9\frac{3}{4}$
27	$10\frac{1}{8}$
27	$10\frac{1}{2}$
27	$10\frac{7}{8}$
27	$11\frac{1}{4}$
27	$11\frac{3}{4}$
28	$0\frac{1}{8}$

9	$0\frac{5}{8}$
9	$0\frac{3}{4}$
9	$0\frac{7}{8}$
9	1
9	$1\frac{1}{8}$
9	$1\frac{1}{4}$
9	$1\frac{3}{8}$
9	$1\frac{1}{2}$
9	$1\frac{5}{8}$
9	$1\frac{3}{4}$
9	$1\frac{7}{8}$
9	2
9	$2\frac{1}{8}$
9	$2\frac{1}{4}$
9	$2\frac{3}{8}$
9	$2\frac{1}{2}$
9	$2\frac{5}{8}$
9	$2\frac{3}{4}$
9	$2\frac{7}{8}$
9	3
9	$3\frac{1}{8}$
9	$3\frac{1}{4}$
9	$3\frac{3}{8}$
9	$3\frac{1}{2}$

28	$5\frac{1}{4}$
28	$5\frac{5}{8}$
28	6
28	$6\frac{3}{8}$
28	$6\frac{3}{4}$
28	$7\frac{1}{8}$
28	$7\frac{1}{2}$
28	8
28	$8\frac{3}{8}$
28	$8\frac{3}{4}$
28	$9\frac{1}{8}$
28	$9\frac{1}{2}$
28	$9\frac{7}{8}$
28	$10\frac{1}{4}$
28	$10\frac{3}{4}$
28	$11\frac{1}{8}$
28	$11\frac{1}{2}$
28	$11\frac{7}{8}$
29	$0\frac{1}{4}$
29	$0\frac{5}{8}$
29	1
29	$1\frac{1}{2}$
29	$1\frac{7}{8}$
29	$2\frac{1}{4}$

9	5
9	$5\frac{1}{8}$
9	$5\frac{1}{4}$
9	$5\frac{3}{8}$
9	$5\frac{1}{2}$
9	$5\frac{5}{8}$
9	$5\frac{3}{4}$
9	$5\frac{7}{8}$
9	6
9	$6\frac{1}{8}$
9	$6\frac{1}{4}$
9	$6\frac{3}{8}$
9	$6\frac{1}{2}$
9	$6\frac{5}{8}$
9	$6\frac{3}{4}$
9	$6\frac{7}{8}$
9	7
9	$7\frac{1}{8}$
9	$7\frac{1}{4}$
9	$7\frac{3}{8}$
9	$7\frac{1}{2}$
9	$7\frac{5}{8}$
9	$7\frac{3}{4}$
9	$7\frac{7}{8}$

29	7
29	$7\frac{3}{8}$
29	$7\frac{3}{4}$
29	$8\frac{1}{8}$
29	$8\frac{1}{2}$
29	$8\frac{7}{8}$
29	$9\frac{1}{4}$
29	$9\frac{3}{4}$
29	$10\frac{1}{8}$
29	$10\frac{1}{2}$
29	$10\frac{7}{8}$
29	$11\frac{1}{4}$
29	$11\frac{5}{8}$
30	0
30	$0\frac{1}{2}$
30	$0\frac{7}{8}$
30	$1\frac{1}{4}$
30	$1\frac{5}{8}$
30	2
30	$2\frac{3}{8}$
30	$2\frac{3}{4}$
30	$3\frac{1}{8}$
30	$3\frac{5}{8}$
30	4

9	
9	
9	
9	
9	
9	
9	1
9	1
9	1
9	1
9	1
9	1
9	1
9	1
9	1
9	
9	
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9	
9	
9	
9	
10	

n.	Circum.		Diam.		Circum.		Diam.		Circum.		Diam.		Circum.	
In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
1⅛	31	8½	10	5½	32	10¼	10	9⅞	34	0	11	2⅛	35	1¼
1¼	31	8⅞	10	5⅝	32	10⅝	10	10	34	0⅜	11	2¼	35	1¾
1⅜	31	9¼	10	5¾	32	11					11	2⅜	35	2⅛
1½	31	9⅝	10	5⅞	32	11⅜	10	10⅛	34	0¾	11	2½	35	2½
1⅝	31	10	10	6	32	11¾	10	10¼	34	1⅛	11	2⅝	35	2⅞
1¾	31	10⅜	10	6⅛	33	0⅛	10	10⅜	34	1½	11	2¾	35	3¼
1⅞	31	10⅞	10	6¼	33	0⅝	10	10½	34	1⅞	11	2⅞	35	3⅝
2	31	11¼	10	6⅜	33	1	10	10⅝	34	2⅜	11	3	35	4
2⅛	31	11⅝	10	6½	33	1⅜	10	10¾	34	2¾	11	3⅛	35	4½
2¼	32	0	10	6⅝	33	1¾	10	10⅞	34	3⅛	11	3¼	35	4⅞
2⅜	32	0⅜	10	6¾	33	2⅛	10	11	34	3½	11	3⅜	35	5¼
2½	32	0¾	10	6⅞	33	2½	10	11⅛	34	3⅞	11	3½	35	5⅝
2⅝	32	1⅛	10	7	33	2⅞	10	11¼	34	4¼	11	3⅝	35	6
2¾	32	1½	10	7⅛	33	3⅜	10	11⅜	34	4⅝	11	3¾	35	6⅜
2⅞	32	2	10	7¼	33	3¾	10	11½	34	5	11	3⅞	35	6¾
3	32	2⅜	10	7⅜	33	4⅛	10	11⅝	34	5½	11	4	35	7¼
3⅛	32	2¾	10	7½	33	4½	10	11¾	34	5⅞	11	4⅛	35	7⅝
3¼	32	3⅛	10	7⅝	33	4⅞	10	11⅞	34	6¼	11	4¼	35	8
3⅜	32	3½	10	7¾	33	5¼	11	0	34	6⅝	11	4⅜	35	8⅜
3½	32	3⅞	10	7⅞	33	5⅝	11	0⅛	34	7	11	4½	35	8¾
3⅝	32	4⅜	10	8	33	6⅛	11	0¼	34	7⅜	11	4⅝	35	9⅛
3¾	32	4¾	10	8⅛	33	6½	11	0⅜	34	7¾	11	4¾	35	9½
3⅞	32	5⅛	10	8¼	33	6⅞	11	0½	34	8¼	11	4⅞	35	10
4	32	5½	10	8⅜	33	7¼	11	0⅝	34	8⅝	11	5	35	10⅜
4⅛	32	5⅞	10	8½	33	7⅝	11	0¾	34	9	11	5⅛	35	10¾
4¼	32	6¼	10	8⅝	33	8	11	0⅞	34	9⅜	11	5¼	35	11⅛
4⅜	32	6⅝	10	8¾	33	8⅜	11	1	34	9¾	11	5⅜	35	11½
4½	32	7	10	8⅞	33	8⅞	11	1⅛	34	10⅛	11	5½	35	11⅞
4⅝	32	7½	10	9	33	9¼	11	1¼	34	10½	11	5⅝	36	0¼
4¾	32	7⅞	10	9⅛	33	9⅝	11	1⅜	34	11	11	5¾	36	0¾
4⅞	32	8¼	10	9¼	33	10	11	1½	34	11⅜	11	5⅞	36	1⅛
5	32	8⅝	10	9⅜	33	10⅜	11	1⅝	34	11¾	11	6	36	1½
5⅛	32	9	10	9½	33	10¾	11	1¾	35	0⅛	11	6⅛	36	1⅞
5¼	32	9⅜	10	9⅝	33	11⅛	11	1⅞	35	0½	11	6¼	36	2¼
5⅜	32	9⅞	10	9¾	33	11½	11	2	35	0⅞	11	6⅜	36	2⅝

36	4⅝	11	11¼	37	6	12	3⅝	38	7¾	12
36	5	11	11⅜	37	6⅜	12	3¾	38	8⅛	12
36	5⅜	11	11½	37	6¾	12	3⅞	38	8½	12
36	5⅞	11	11⅝	37	7⅛	12	4	38	8⅞	12
36	6¼	11	11¾	37	7½	12	4⅛	38	9¼	12
36	6⅝	11	11⅞	37	7⅞	12	4¼	38	9⅝	12
36	7	12	0	37	8⅜	12	4⅜	38	10⅛	12
36	7⅜	12	0⅛	37	8¾	12	4½	38	10½	12
36	7¾	12	0¼	37	9⅛	12	4⅝	38	10⅞	12
36	8⅛	12	0⅜	37	9½	12	4¾	38	11¼	12
36	8½	12	0½	37	9⅞	12	4⅞	38	11⅝	12
36	9	12	0⅝	37	10¼	12	5	39	0	12
36	9⅜	12	0¾	37	10⅝	12	5⅛	39	0⅜	12
36	9¾	12	0⅞	37	11⅛	12	5¼	39	0⅞	12
36	10⅛	12	1	37	11½	12	5⅜	39	1¼	12
36	10½	12	1⅛	37	11¾	12	5½	39	1⅝	12
36	10⅞	12	1¼	38	0¼	12	5⅝	39	2	12
36	11¼	12	1⅜	38	0⅝	12	5¾	39	2⅜	12
36	11¾	12	1½	38	1	12	5⅞	39	2¾	12
37	0⅛	12	1⅝	38	1⅜	12	6	39	3⅛	12
37	0½	12	1¾	38	1⅞	12	6⅛	39	3⅝	12
37	0⅞	12	1⅞	38	2¼	12	6¼	39	4	12
37	1¼	12	2	38	2⅝	12	6⅜	39	4⅜	12

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
12	11⅞	40	9⅝
13	0	40	10
13	0⅛	40	10⅜
13	0¼	40	10⅞
13	0⅜	40	11¼
13	0½	40	11⅝
13	0⅝	41	0
13	0¾	41	0⅜
13	0⅞	41	0¾
13	1	41	1⅛
13	1⅛	41	1½
13	1¼	41	2
13	1⅜	41	2⅜
13	1½	41	2¾
13	1⅝	41	3⅛
13	1¾	41	3½
13	1⅞	41	3⅞
13	2	41	4¼
13	2⅛	41	4¾
13	2¼	41	5⅛
13	2⅜	41	5½
13	2½	41	5⅞
13	2⅝	41	6¼
13	2¾	41	6⅝
13	2⅞	41	7
13	3	41	7½
13	3⅛	41	7⅞
13	3¼	41	8¼
13	3⅜	41	8⅝
13	3½	41	9
13	3⅝	41	9⅜
13	3¾	41	9¾
13	3⅞	41	10¼
13	4	41	10⅝
13	4⅛	41	11
13	4¼	41	11⅜
13	4⅜	41	11¾
13	4½	42	0⅛
13	4⅝	42	0½
13	4¾	42	1
13	4⅞	42	1⅜
13	5	42	1¾
13	5⅛	42	2⅛
13	5¼	42	2½
13	5⅜	42	2⅞
13	5½	42	3¼
13	5⅝	42	3¾
13	5¾	42	4⅛
13	5⅞	42	4½
13	6	42	4⅞
13	6⅛	42	5¼
13	6¼	42	5⅝
13	6⅜	42	6
13	6½	42	6½
13	6⅝	42	6⅞
13	6¾	42	7¼
13	6⅞	42	7⅝
13	7	42	8
13	7⅛	42	8⅜
13	7¼	42	8⅞
13	7⅜	42	9¼
13	7½	42	9⅝
13	7⅝	42	10
13	7¾	42	10⅜
13	7⅞	42	10¾
13	8	42	11⅛
13	8⅛	42	11½
13	8¼	43	0
13	8⅜	43	0⅜
13	8½	43	0¾
13	8⅝	43	1⅛
13	8¾	43	1½
13	8⅞	43	1⅞
13	9	43	2¼
13	9⅛	43	2¾
13	9¼	43	3⅛
13	9⅜	43	3½
13	9½	43	3⅞
13	9⅝	43	4¼
13	9¾	43	4⅝
13	9⅞	43	5
13	10	43	5½
13	10⅛	43	5⅞
13	10¼	43	6¼
13	10⅜	43	6⅝
13	10½	43	7
13	10⅝	43	7⅜
13	10¾	43	7¾
13	10⅞	43	8¼
13	11	43	8⅝
13	11⅛	43	9
13	11¼	43	9⅜
13	11⅜	43	9¾
13	11½	43	10⅛
13	11⅝	43	10½
13	11¾	43	11
13	11⅞	43	11⅜
14	0	43	11¾
14	0⅛	44	0⅛
14	0¼	44	0½
14	0⅜	44	0⅞
14	0½	44	1¼
14	0⅝	44	1¾
14	0¾	44	2⅛
14	0⅞	44	
14	1	44	
14	1⅛	44	
14	1¼	44	
14	1⅜	44	
14	1½	44	
14	1⅝	44	
14	1¾	44	
14	1⅞	44	
14	2	44	
14	2⅛	44	
14	2¼	44	
14	2⅜	44	
14	2½	44	
14	2⅝	44	
14	2¾	44	
14	2⅞	44	
14	3	44	
14	3⅛	44	
14	3¼	44	
14	3⅜	44	
14	3½	44	
14	3⅝	44	
14	3¾	44	
14	3⅞	44	
14	4	45	
14	4⅛	45	
14	4¼	45	
14	4⅜	45	
14	4½	45	
14	4⅝	45	
14	4¾	45	
14	4⅞	45	
14	5	45	

	6¾	36	3⅞
	6⅞	36	4¼
	7	36	4⅝
	7⅛	36	5
	7¼	36	5⅜
	7⅜	36	5⅞
	7½	36	6¼
	7⅝	36	6⅝
	7¾	36	7
	7⅞	36	7⅜
	8	36	7¾
	8⅛	36	8⅛
	8¼	36	8½
1	8⅜	36	9
1	8½	36	9⅜
1	8⅝	36	9¾
1	8¾	36	10⅛
1	8⅞	36	10½
1	9	36	10⅞
1	9⅛	36	11¼
1	9¼	36	11¾
1	9⅜	37	0⅛
11	9½	37	0½
11	9⅝	37	0⅞

11	11⅛	37	5⅝
11	11¼	37	6
11	11⅜	37	6⅜
11	11½	37	6¾
11	11⅝	37	7⅛
11	11¾	37	7½
11	11⅞	37	7⅞
12	0	37	8⅜
12	0⅛	37	8¾
12	0¼	37	9⅛
12	0⅜	37	9½
12	0½	37	9⅞
12	0⅝	37	10¼
12	0¾	37	10⅝
12	0⅞	37	11⅛
12	1	37	11½
12	1⅛	37	11¾
12	1¼	38	0¼
12	1⅜	38	0⅝
12	1½	38	1
12	1⅝	38	1⅜
12	1¾	38	1⅞
12	1⅞	38	2¼

12	[illegible]	38	[illegible]
12	3½	38	7⅝
12	3⅝	38	7¾
12	3¾	38	8⅛
12	3⅞	38	8½
12	4	38	8⅞
12	4⅛	38	9¼
12	4¼	38	9⅝
12	4⅜	38	10⅛
12	4½	38	10½
12	4⅝	38	10⅞
12	4¾	38	11¼
12	4⅞	38	11⅝
12	5	39	0
12	5⅛	39	0⅜
12	5¼	39	0⅞
12	5⅜	39	1¼
12	5½	39	1⅝
12	5⅝	39	2
12	5¾	39	2⅜
12	5⅞	39	2¾
12	6	39	3⅛
12	6⅛	39	3⅝
12	6¼	39	4

CIRCLES ADVANCING BY AN EIGHTH.

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.	Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.	Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.	Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
12	11⅞	40	9⅝	13	4⅛	41	11	13	8½	43	0¾	14	0⅞	44	[illegible]
13	0	40	10	13	4¼	41	11⅜	13	8⅝	43	1⅛	14	1	44	[illegible]
13	0⅛	40	10⅜	13	4⅜	41	11¾	13	8¾	43	1½	14	1⅛	44	[illegible]
13	0¼	40	10⅞	13	4½	42	0⅛	13	8⅞	43	1⅞	14	1¼	44	[illegible]
13	0⅜	40	11¼	13	4⅝	42	0½	13	9	43	2¼	14	1⅜	44	[illegible]
13	0½	40	11⅝	13	4¾	42	1	13	9⅛	43	2¾	14	1½	44	[illegible]
13	0⅝	41	0	13	4⅞	42	1⅜	13	9¼	43	3⅛	14	1⅝	44	[illegible]
13	0¾	41	0⅜	13	5	42	1¾	13	9⅜	43	3½	14	1¾	44	[illegible]
13	0⅞	41	0¾	13	5⅛	42	2⅛	13	9½	43	3⅞	14	1⅞	44	[illegible]
13	1	41	1⅛	13	5¼	42	2½	13	9⅝	43	4¼	14	2	44	[illegible]
13	1⅛	41	1½	13	5⅜	42	2⅞	13	9¾	43	4⅝	14	2⅛	44	[illegible]
13	1¼	41	2	13	5½	42	3¼	13	9⅞	43	5	14	2¼	44	[illegible]
13	1⅜	41	2⅜	13	5⅝	42	3¾	13	10	43	5½	14	2⅜	44	[illegible]
13	1½	41	2¾	13	5¾	42	4⅛	13	10⅛	43	5⅞	14	2½	44	[illegible]
13	1⅝	41	3⅛	13	5⅞	42	4½	13	10¼	43	6¼	14	2⅝	44	[illegible]
13	1¾	41	3½	13	6	42	4⅞	13	10⅜	43	6⅝	14	2¾	44	[illegible]
13	1⅞	41	3⅞	13	6⅛	42	5¼	13	10½	43	7	14	2⅞	44	[illegible]
13	2	41	4¼	13	6¼	42	5⅝	13	10⅝	43	7⅜	14	3	44	[illegible]
13	2⅛	41	4¾	13	6⅜	42	6	13	10¾	43	7¾	14	3⅛	44	[illegible]
13	2¼	41	5⅛	13	6½	42	6½	13	10⅞	43	8¼	14	3¼	44	[illegible]
13	2⅜	41	5½	13	6⅝	42	6⅞	13	11	43	8⅝	14	3⅜	44	[illegible]
13	2½	41	5⅞	13	6¾	42	7¼	13	11⅛	43	9	14	3½	44	[illegible]
13	2⅝	41	6¼	13	6⅞	42	7⅝	13	11¼	43	9⅜	14	3⅝	44	[illegible]
13	2¾	41	6⅝	13	7	42	8	13	11⅜	43	9¾	14	3¾	44	[illegible]
13	2⅞	41	7	13	7⅛	42	8⅜	13	11½	43	10⅛	14	3⅞	44	[illegible]
13	3	41	7½	13	7¼	42	8⅞	13	11⅝	43	10½	14	4	45	[illegible]
13	3⅛	41	7⅞	13	7⅜	42	9¼	13	11¾	43	11	14	4⅛	45	[illegible]
13	3¼	41	8¼	13	7½	42	9⅝	13	11⅞	43	11⅜	14	4¼	45	[illegible]
13	3⅜	41	8⅝	13	7⅝	42	10	14	0	43	11¾	14	4⅜	45	[illegible]
13	3½	41	9	13	7¾	42	10⅜	14	0⅛	44	0⅛	14	4½	45	[illegible]
13	3⅝	41	9⅜	13	7⅞	42	10¾	14	0¼	44	0½	14	4⅝	45	[illegible]
13	3¾	41	9¾	13	8	42	11⅛	14	0⅜	44	0⅞	14	4¾	45	[illegible]
13	3⅞	41	10¼	13	8⅛	42	11½	14	0½	44	1¼	14	4⅞	45	[illegible]
13	4	41	10⅝	13	8¼	43	0	14	0⅝	44	1¾	14	5	45	[illegible]
				13	8⅜	43	0⅜	14	0¾	44	2⅛				

45	5
45	5⅜
45	5¾
45	6¼
45	6⅝
45	7
45	7⅜
45	7¾
45	8⅛
45	8½
45	9
45	9⅜
45	9¾
45	10⅛
45	10½
45	10⅞
45	11¼
45	11⅝
46	0⅛
46	0½
46	0⅞
46	1¼
46	1⅝
46	2

14	9⅞	46	6¾
14	10	46	7⅛
14	10⅛	46	7½
14	10¼	46	7⅞
14	10⅜	46	8⅜
14	10½	46	8¾
14	10⅝	46	9⅛
14	10¾	46	9½
14	10⅞	46	9⅞
14	11	46	10¼
14	11⅛	46	10⅝
14	11¼	46	11⅛
14	11⅜	46	11½
14	11½	46	11⅞
14	11⅝	47	0¼
14	11¾	47	0⅝
14	11⅞	47	1
15	0	47	1½
15	0⅛	47	1⅞
15	0¼	47	2¼
15	0⅜	47	2⅝
15	0½	47	3
15	0⅝	47	3⅜
15	0¾	47	3¾

15	2⅛	47	8⅛
15	2¼	47	8½
15	2⅜	47	8⅞
15	2½	47	9¼
15	2⅝	47	9⅝
15	2¾	47	10⅛
15	2⅞	47	10½
15	3	47	10⅞
15	3⅛	47	11¼
15	3¼	47	11⅝
15	3⅜	48	0
15	3½	48	0⅜
15	3⅝	48	0⅞
15	3¾	48	1¼
15	3⅞	48	1⅝
15	4	48	2
15	4⅛	48	2⅜
15	4¼	48	2¾
15	4⅜	48	3⅛
15	4½	48	3½
15	4⅝	48	4
15	4¾	48	4⅜
15	4⅞	48	4¾
15	5	48	5⅛

15	[illegible]
15	[illegible]
15	[illegible]
15	[illegible]
15	[illegible]
15	7
15	7
15	7
15	7
15	7
15	7
15	7
15	8
15	8
15	8
15	8
15	8
15	8
15	8
15	8
15	9
15	9
15	9
15	9

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
15	10½	49	10½
15	10⅝	49	10⅞
15	10¾	49	11¼
15	10⅞	49	11⅝
15	11	50	0
15	11⅛	50	0½
15	11¼	50	0⅞
15	11⅜	50	1¼
15	11½	50	1⅝
15	11⅝	50	2
15	11¾	50	2⅜
15	11⅞	50	2¾
16	0	50	3⅛
16	0⅛	50	3½
16	0¼	50	3⅞
16	0⅜	50	4¼
16	0½	50	4¾
16	0⅝	50	5⅛
16	0¾	50	5½
16	0⅞	50	5⅞
16	1	50	6¼
16	1⅛	50	6⅝
16	1¼	50	7
16	1⅜	50	7½
16	1½	50	7⅞
16	1⅝	50	8¼
16	1¾	50	8⅝
16	1⅞	50	9
16	2	50	9⅜
16	2⅛	50	9¾
16	2¼	50	10¼
16	2⅜	50	10⅝
16	2½	50	11
16	2⅝	50	11⅜
16	2¾	50	11¾

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	2⅞	51	0⅛
16	3	51	0½
16	3⅛	51	1
16	3¼	51	1⅜
16	3⅜	51	1¾
16	3½	51	2⅛
16	3⅝	51	2½
16	3¾	51	2⅞
16	3⅞	51	3¼
16	4	51	3¾
16	4⅛	51	4⅛
16	4¼	51	4½
16	4⅜	51	4⅞
16	4½	51	5¼
16	4⅝	51	5⅝
16	4¾	51	6
16	4⅞	51	6½
16	5	51	6⅞
16	5⅛	51	7¼
16	5¼	51	7⅝
16	5⅜	51	8
16	5½	51	8⅜
16	5⅝	51	8¾
16	5¾	51	9¼
16	5⅞	51	9½
16	6	51	10
16	6⅛	51	10⅜
16	6¼	51	10¾
16	6⅜	51	11⅛
16	6½	51	11½
16	6⅝	52	0
16	6¾	52	0⅜
16	6⅞	52	0¾
16	7	52	1⅛

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	7⅛	52	1½
16	7¼	52	1⅞
16	7⅜	52	2¼
16	7½	52	2⅝
16	7⅝	52	3⅛
16	7¾	52	3½
16	7⅞	52	3⅞
16	8	52	4¼
16	8⅛	52	4⅝
16	8¼	52	5
16	8⅜	52	5⅜
16	8½	52	5⅞
16	8⅝	52	6¼
16	8¾	52	6⅝
16	8⅞	52	7
16	9	52	7⅜
16	9⅛	52	7¾
16	9¼	52	8¼
16	9⅜	52	8⅝
16	9½	52	9
16	9⅝	52	9⅜
16	9¾	52	9¾
16	9⅞	52	10⅛
16	10	52	10½
16	10⅛	52	11
16	10¼	52	11⅜
16	10⅜	52	11¾
16	10½	53	0⅛
16	10⅝	53	0½
16	10¾	53	0⅞
16	10⅞	53	1¼
16	11	53	1⅝
16	11⅛	53	2
16	11¼	53	2½
16	11⅜	53	2⅞

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	11½	53	3¼
16	11⅝	53	3⅝
16	11¾	53	4
16	11⅞	53	4½
17	0	53	4⅞
17	0⅛	53	5¼
17	0¼	53	5⅝
17	0⅜	53	6
17	0½	53	6⅜
17	0⅝	53	6¾
17	0¾	53	7¼
17	0⅞	53	7⅝
17	1	53	8
17	1⅛	53	8⅜
17	1¼	53	8¾
17	1⅜	53	9⅛
17	1½	53	9½
17	1⅝	53	10
17	1¾	53	10⅜
17	1⅞	53	10¾
17	2	53	11⅛
17	2⅛	53	11½
17	2¼	53	11⅞
17	2⅜	54	0¼
17	2½	54	0⅝
17	2⅝	54	1⅛
17	2¾	54	1½
17	2⅞	54	1⅞
17	3	54	2¼
17	3⅛	54	2⅝
17	3¼	54	3
17	3⅜	54	3½
17	3½	54	3⅞
17	3⅝	54	4¼
17	3¾	54	4⅝

54	5¾
54	6⅛
54	6⅝
54	7
54	7⅜
54	7¾
54	8⅛
54	8½
54	8⅞
54	9⅜
54	9¾
54	10⅛
54	10½
54	10⅞
54	11¼
54	11⅝
55	0⅛
55	0½
55	0⅞
55	1¼
55	1⅝
55	2
55	2⅜
55	2⅞

17	8½	55	7½
17	8⅝	55	7⅞
17	8¾	55	8⅜
17	8⅞	55	8¾
17	9	55	9⅛
17	9⅛	55	9½
17	9¼	55	9⅞
17	9⅜	55	10¼
17	9½	55	10⅝
17	9⅝	55	11⅛
17	9¾	55	11½
17	9⅞	55	11⅞
17	10	56	0¼
17	10⅛	56	0⅝
17	10¼	56	1
17	10⅜	56	1⅜
17	10½	56	1⅞
17	10⅝	56	2¼
17	10¾	56	2⅝
17	10⅞	56	3
17	11	56	3⅜
17	11⅛	56	3¾
17	11¼	56	4⅛
17	11⅜	56	4½

18	0⅞	56	9¼
18	1	56	9⅝
18	1⅛	56	10
18	1¼	56	10½
18	1⅜	56	10⅞
18	1½	56	11¼
18	1⅝	56	11⅝
18	1¾	57	0
18	1⅞	57	0⅜
18	2	57	0¾
18	2⅛	57	1¼
18	2¼	57	1⅝
18	2⅜	57	2
18	2½	57	2⅜
18	2⅝	57	2¾
18	2¾	57	3⅛
18	2⅞	57	3½
18	3	57	4
18	3⅛	57	4⅜
18	3¼	57	4¾
18	3⅜	57	5⅛
18	3½	57	5½
18	3⅝	57	5⅞
18	3¾	57	6⅜

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Diam.		Circum.		Diam.		Circum.		Diam.		Circum.		Diam.		Circum.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
18	9⅛	58	11¼	19	1⅛	59	11¾	19	5⅛	61	0⅜	19	9⅛	62	0⅞
18	9¼	58	11⅝	19	1¼	60	0⅛	19	5¼	61	0¾	19	9¼	62	1¼
18	9⅜	59	0	19	1⅜	60	0½	19	5⅜	61	1⅛	19	9⅜	62	1⅝
18	9½	59	0⅜	19	1½	60	1	19	5½	61	1½	19	9½	62	2⅛
18	9⅝	59	0¾	19	1⅝	60	1⅜	19	5⅝	61	1⅞	19	9⅝	62	2½
18	9¾	59	1¼	19	1¾	60	1¾	19	5¾	61	2¼	19	9¾	62	2⅞
18	9⅞	59	1⅝	19	1⅞	60	2⅛	19	5⅞	61	2¾	19	9⅞	62	3¼
18	10	59	2	19	2	60	2½	19	6	61	3⅛	19	10	62	3⅝
18	10⅛	59	2⅜	19	2⅛	60	2⅞	19	6⅛	61	3½	19	10⅛	62	4
18	10¼	59	2¾	19	2¼	60	3¼	19	6¼	61	3⅞	19	10¼	62	4⅜
18	10⅜	59	3⅛	19	2⅜	60	3⅝	19	6⅜	61	4¼	19	10⅜	62	4⅞
18	10½	59	3½	19	2½	60	4⅛	19	6½	61	4⅝	19	10½	62	5¼
18	10⅝	59	3⅞	19	2⅝	60	4½	19	6⅝	61	5	19	10⅝	62	5⅝
18	10¾	59	4¼	19	2¾	60	4⅞	19	6¾	61	5½	19	10¾	62	6
18	10⅞	59	4¾	19	2⅞	60	5¼	19	6⅞	61	5⅞	19	10⅞	62	6⅜
18	11	59	5⅛	19	3	60	5⅝	19	7	61	6¼	19	11	62	6¾
18	11⅛	59	5½	19	3⅛	60	6	19	7⅛	61	6⅝	19	11⅛	62	7⅛
18	11¼	59	5⅞	19	3¼	60	6⅜	19	7¼	61	7	19	11¼	62	7½
18	11⅜	59	6¼	19	3⅜	60	6⅞	19	7⅜	61	7⅜	19	11⅜	62	8
18	11½	59	6⅝	19	3½	60	7¼	19	7½	61	7¾	19	11½	62	8⅜
18	11⅝	59	7	19	3⅝	60	7⅝	19	7⅝	61	8¼	19	11⅝	62	8¾
18	11¾	59	7½	19	3¾	60	8	19	7¾	61	8⅝	19	11¾	62	9⅛
18	11⅞	59	7⅞	19	3⅞	60	8⅜	19	7⅞	61	9	19	11⅞	62	9½
19	0	59	8¼	19	4	60	8¾	19	8	61	9⅜	20	0	62	9⅞
19	0⅛	59	8⅝	19	4⅛	60	9¼	19	8⅛	61	9¾	20	0⅛	62	10⅜
19	0¼	59	9	19	4¼	60	9⅝	19	8¼	61	10⅛	20	0¼	62	10¾
19	0⅜	59	9⅜	19	4⅜	60	10	19	8⅜	61	10½	20	0⅜	62	11⅛
19	0½	59	9¾	19	4½	60	10⅜	19	8½	61	11	20	0½	62	11½
19	0⅝	59	10¼	19	4⅝	60	10¾	19	8⅝	61	11⅜	20	0⅝	62	11⅞
19	0¾	59	10⅝	19	4¾	60	11⅛	19	8¾	61	11¾	20	0¾	63	0¼
19	0⅞	59	11	19	4⅞	60	11½	19	8⅞	62	0⅛	20	0⅞	63	0⅝
19	1	59	11⅜	19	5	60	11⅞	19	9	62	0½				

... ... prove the general utility of these T
their simplicity and clearness are sufficient
their value to the artist and mechanic. I
clearly perceived, on inspection, that the Ta
mences with as small a diameter as is gener
in hoops and rings, viz. one inch, and inc
the regular gradation of one-eighth of an
upwards of twenty feet; and in the colum
Circumference, against each Diameter stan
spective circumferences: hence all that is
on inspecting these Tables is to enter into th
any proposed diameter or circumference,
answer to the inquiry is immediately obtain

Example.—Required the circumference of
the diameter being 11 feet 7⅛ inches.

In the column of circumferences, oppo
given diameter, stands 36 feet 7⅜ inches, the
ference required.

But it will be necessary to observe, that
formation of hoops and rings a contractio
metal takes place. Now, the just allowance
contraction is the exact thickness of the meta
must ...

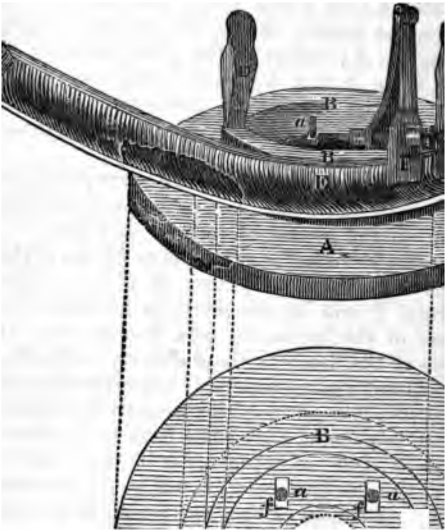
The foregoing example appertains to the formation of hoops or iron bent on the flat; but in the formation of rings or iron bent on the edge, the same rule must also be followed, only taking care to add the *breadth* instead of the thickness. As for example:

To make a ring whose inside diameter is 8 feet $2\frac{1}{4}$ inches, the *breadth* of the iron being $2\frac{1}{2}$ inches; by adding the $2\frac{1}{2}$ inches to the given diameter, will increase it to 8 feet $4\frac{3}{4}$ inches; opposite to this diameter in the column of circumferences stands 26 feet $4\frac{1}{2}$ inches, being the length of iron necessary for the ring.

The foregoing observations relate more particularly to plain hoops and rings; but as respects the hoops that are on the wheels of railway carriages, a difference must be observed, which is as follows: These hoops having a flange projecting on the one edge of the surface it will be necessary, in addition to the thickness of the metal, to add two-thirds of the thickness of the flange to the diameter, as the flange side would contract considerably more than the plain surface; this is supposing the tires are in a straight form, but, in general, they come from the iron-works in a curved state, as represented in the engraving, figure 3. In the latter case, it will be only necessary to add the thickness of the bare metal, as the aforesaid portion of the thickness of the flange is allowed for in the curve. By having had some experience in hoops of this nature, I have found that the curve may be exactly obtained, by using four times the circumference of the hoop as a radius.

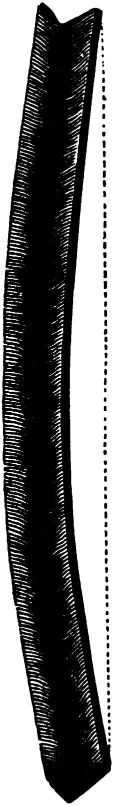
In the engraving, fig. 1, is given a representation of a tire in its curved state, fixed to the blocks, and in the act of being bent; but if the tire has not been previously curved, it may easily be done in the

Figures 1 and 2.



The following is a description of the figures 1 and 2: A is a strong cast-iron ground-plate, in which *f f f f* are four slot-holes for the bolts *a a a a* to slide in, and are for the purpose of screwing down the two semicircular blocks, to prevent them from moving whilst the tire is in the act of being bent. B B is the block in two halves, opening at C C; the aperture is cut in a conical form, for the reception of the two conical wedges D D, on which the tire E is represented. *h h* are two holes in the ground-plate, into which the wedges are driven whilst blocking the hoop. F is a strong cramp for screwing the tire firm to the block whilst in the act of being bent round it: it is made with a joint at the top, and secures the tire to the block by means of a strong square-threaded screw, which screws into a boss on the innermost leg.

Figure 3.



But the practical utility of this Table is not confined to smiths alone; to the millwright it will be found equally useful and expeditious, as on a bare inspection of the Table he may ascertain the diameter of any wheel that may be required to be made, the pitch and number of teeth being given.

Ex. Suppose a wheel were ordered to be made to contain sixty teeth, the pitch of the teeth to be 3⅛ inches, the dimensions of the wheel may be ascertained simply as follows:

Multiply the pitch of the tooth by the

5	5⅜	14	10	46	7⅛	15	2¼	47	8½	15
5	5¾	14	10⅛	46	7½	15	2⅜	47	8⅞	15
5	6¼	14	10¼	46	7⅞	15	2½	47	9¼	15
5	6⅝	14	10⅜	46	8⅜	15	2⅝	47	9⅝	15
5	7	14	10½	46	8¾	15	2¾	47	10⅛	15
5	7⅜	14	10⅝	46	9⅛	15	2⅞	47	10½	15
5	7¾	14	10¾	46	9½	15	3	47	10⅞	15
5	8⅛	14	10⅞	46	9⅞	15	3⅛	47	11¼	15
5	8½	14	11	46	10¼	15	3¼	47	11⅝	15
5	9	14	11⅛	46	10⅝	15	3⅜	48	0	15
5	9⅜	14	11¼	46	11⅛	15	3½	48	0⅜	15
5	9¾	14	11⅜	46	11½	15	3⅝	48	0⅞	15
45	10⅛	14	11½	46	11⅞	15	3¾	48	1¼	15
45	10½	14	11⅝	47	0¼	15	3⅞	48	1⅝	15
45	10⅞	14	11¾	47	0⅝	15	4	48	2	15
45	11¼	14	11⅞	47	1	15	4⅛	48	2⅜	15
45	11⅝	15	0	47	1½	15	4¼	48	2¾	15
46	0⅛	15	0⅛	47	1⅞	15	4⅜	48	3⅛	15
46	0½	15	0¼	47	2¼	15	4½	48	3½	15
46	0⅞	15	0⅜	47	2⅝	15	4⅝	48	4	15
46	1¼	15	0½	47	3	15	4¾	48	4⅜	15
46	1⅝	15	0⅝	47	3⅜	15	4⅞	48	4¾	15
46	2	15	0¾	47	3¾	15	5	48	5⅛	15
46	2⅜	15	0⅞	47	4⅛					15

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
5	10½	49	10½
5	10⅝	49	10⅞
5	10¾	49	11¼
5	10⅞	49	11⅝
5	11	50	0
5	11⅛	50	0½
5	11¼	50	0⅞
5	11⅜	50	1¼
5	11½	50	1⅝
5	11⅝	50	2
5	11¾	50	2⅜
5	11⅞	50	2¾
5	0	50	3⅛
5	0⅛	50	3½
5	0¼	50	3⅞
5	0⅜	50	4¼
5	0½	50	4¾
5	0⅝	50	5⅛
5	0¾	50	5½
5	0⅞	50	5⅞
5	1	50	6¼
5	1⅛	50	6⅝
5	1¼	50	7
5	1⅜	50	7½
5	1½	50	7⅞
5	1⅝	50	8¼
5	1¾	50	8⅝
5	1⅞	50	9
5	2	50	9⅜
5	2⅛	50	9¾
5	2¼	50	10¼
5	2⅜	50	10⅝
5	2½	50	11
5	2⅝	50	11⅜
5	2¾	50	11¾

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	2⅞	51	0⅛
16	3	51	0½
16	3⅛	51	1
16	3¼	51	1⅜
16	3⅜	51	1¾
16	3½	51	2⅛
16	3⅝	51	2½
16	3¾	51	2⅞
16	3⅞	51	3¼
16	4	51	3¾
16	4⅛	51	4⅛
16	4¼	51	4½
16	4⅜	51	4⅞
16	4½	51	5¼
16	4⅝	51	5⅝
16	4¾	51	6
16	4⅞	51	6½
16	5	51	6⅞
16	5⅛	51	7¼
16	5¼	51	7⅝
16	5⅜	51	8
16	5½	51	8⅜
16	5⅝	51	8¾
16	5¾	51	9¼
16	5⅞	51	9½
16	6	51	10
16	6⅛	51	10⅜
16	6¼	51	10¾
16	6⅜	51	11⅛
16	6½	51	11½
16	6⅝	52	0
16	6¾	52	0⅜
16	6⅞	52	0¾
16	7	52	1⅛

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	7⅛	52	1½
16	7¼	52	1⅞
16	7⅜	52	2¼
16	7½	52	2⅝
16	7⅝	52	3⅛
16	7¾	52	3½
16	7⅞	52	3⅞
16	8	52	4¼
16	8⅛	52	4⅝
16	8¼	52	5
16	8⅜	52	5⅜
16	8½	52	5⅞
16	8⅝	52	6¼
16	8¾	52	6⅝
16	8⅞	52	7
16	9	52	7⅜
16	9⅛	52	7¾
16	9¼	52	8¼
16	9⅜	52	8⅝
16	9½	52	9
16	9⅝	52	9⅜
16	9¾	52	9¾
16	9⅞	52	10⅛
16	10	52	10½
16	10⅛	52	11
16	10¼	52	11⅜
16	10⅜	52	11¾
16	10½	53	0⅛
16	10⅝	53	0½
16	10¾	53	0⅞
16	10⅞	53	1¼
16	11	53	1⅝
16	11⅛	53	2
16	11¼	53	2½
16	11⅜	53	2⅞

Diam. Ft.	Diam. In.	Circum. Ft.	Circum. In.
16	11½	53	3¼
16	11⅝	53	3⅝
16	11¾	53	4
16	11⅞	53	4½
17	0	53	4⅞
17	0⅛	53	5¼
17	0¼	53	5⅝
17	0⅜	53	6
17	0½	53	6⅜
17	0⅝	53	6¾
17	0¾	53	7¼
17	0⅞	53	7⅝
17	1	53	8
17	1⅛	53	8⅜
17	1¼	53	8¾
17	1⅜	53	9⅛
17	1½	53	9½
17	1⅝	53	10
17	1¾	53	10⅜
17	1⅞	53	10¾
17	2	53	11⅛
17	2⅛	53	11½
17	2¼	53	11⅞
17	2⅜	54	0¼
17	2½	54	0⅝
17	2⅝	54	1⅛
17	2¾	54	1½
17	2⅞	54	1⅞
17	3	54	2¼
17	3⅛	54	2⅝
17	3¼	54	3
17	3⅜	54	3½
17	3½	54	3⅞
17	3⅝	54	4¼
17	3¾	54	4⅝

8
$\frac{1}{4}$
$\frac{3}{8}$
$\frac{1}{2}$
$\frac{5}{8}$
$\frac{3}{4}$
$\frac{7}{8}$

54	$5\frac{3}{4}$
54	$6\frac{1}{8}$
54	$6\frac{5}{8}$
54	7
54	$7\frac{3}{8}$
54	$7\frac{3}{4}$
54	$8\frac{1}{8}$
54	$8\frac{1}{2}$
54	$8\frac{7}{8}$
54	$9\frac{3}{8}$
54	$9\frac{3}{4}$
54	$10\frac{1}{8}$
54	$10\frac{1}{2}$
54	$10\frac{7}{8}$
54	$11\frac{1}{4}$
54	$11\frac{5}{8}$
55	$0\frac{1}{8}$
55	$0\frac{1}{2}$
55	$0\frac{7}{8}$
55	$1\frac{1}{4}$
55	$1\frac{5}{8}$
55	2
55	$2\frac{3}{8}$
55	$2\frac{7}{8}$

17	$8\frac{1}{2}$	55	$7\frac{1}{2}$
17	$8\frac{5}{8}$	55	$7\frac{7}{8}$
17	$8\frac{3}{4}$	55	$8\frac{3}{8}$
17	$8\frac{7}{8}$	55	$8\frac{3}{4}$
17	9	55	$9\frac{1}{8}$
17	$9\frac{1}{8}$	55	$9\frac{1}{2}$
17	$9\frac{1}{4}$	55	$9\frac{7}{8}$
17	$9\frac{3}{8}$	55	$10\frac{1}{4}$
17	$9\frac{1}{2}$	55	$10\frac{5}{8}$
17	$9\frac{5}{8}$	55	$11\frac{1}{8}$
17	$9\frac{3}{4}$	55	$11\frac{1}{2}$
17	$9\frac{7}{8}$	55	$11\frac{7}{8}$
17	10	56	$0\frac{1}{4}$
17	$10\frac{1}{8}$	56	$0\frac{5}{8}$
17	$10\frac{1}{4}$	56	1
17	$10\frac{3}{8}$	56	$1\frac{3}{8}$
17	$10\frac{1}{2}$	56	$1\frac{7}{8}$
17	$10\frac{5}{8}$	56	$2\frac{1}{4}$
17	$10\frac{3}{4}$	56	$2\frac{5}{8}$
17	$10\frac{7}{8}$	56	3
17	11	56	$3\frac{3}{8}$
17	$11\frac{1}{8}$	56	$3\frac{3}{4}$
17	$11\frac{1}{4}$	56	$4\frac{1}{8}$
17	$11\frac{3}{8}$	56	$4\frac{1}{2}$

18	$0\frac{7}{8}$	56	$9\frac{1}{4}$
18	1	56	$9\frac{5}{8}$
18	$1\frac{1}{8}$	56	10
18	$1\frac{1}{4}$	56	$10\frac{1}{2}$
18	$1\frac{3}{8}$	56	$10\frac{7}{8}$
18	$1\frac{1}{2}$	56	$11\frac{1}{4}$
18	$1\frac{5}{8}$	56	$11\frac{5}{8}$
18	$1\frac{3}{4}$	57	0
18	$1\frac{7}{8}$	57	$0\frac{3}{8}$
18	2	57	$0\frac{3}{4}$
18	$2\frac{1}{8}$	57	$1\frac{1}{4}$
18	$2\frac{1}{4}$	57	$1\frac{5}{8}$
18	$2\frac{3}{8}$	57	2
18	$2\frac{1}{2}$	57	$2\frac{3}{8}$
18	$2\frac{5}{8}$	57	$2\frac{3}{4}$
18	$2\frac{3}{4}$	57	$3\frac{1}{8}$
18	$2\frac{7}{8}$	57	$3\frac{1}{2}$
18	3	57	4
18	$3\frac{1}{8}$	57	$4\frac{3}{8}$
18	$3\frac{1}{4}$	57	$4\frac{3}{4}$
18	$3\frac{3}{8}$	57	$5\frac{1}{8}$
18	$3\frac{1}{2}$	57	$5\frac{1}{2}$
18	$3\frac{5}{8}$	57	$5\frac{7}{8}$
18	$3\frac{3}{4}$	57	[illegible]

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18	[illegible]
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18	7

Thick.	Broad.	lbs.	oz.	Thick.	Broad.	lbs.	oz.	Thick.	Broad.	lbs.	oz.
in.	in.			in.	in.			in.	in.		
⅛	11⅛	4	9·8	¼	4	3	5·1	¼	8⅝	7	2·5
	11¼	4	10·7		4⅛	3	6·7		8¾	7	4·2
	11⅜	4	11·5		4¼	3	8·4		8⅞	7	5·8
	11½	4	12·3		4⅜	3	10·1		9	7	7·5
	11⅝	4	13·2		4½	3	11·7		9⅛	7	9·1
	11¾	4	14·0		4⅝	3	13·4		9¼	7	10·8
	11⅞	4	14·8		4¾	3	15·0		9⅜	7	12·5
	12	4	15·6		4⅞	4	0·7		9½	7	14·1
					5	4	2·4		9⅝	7	15·8
¼	½	0	6·6		5⅛	4	4·0		9¾	8	1·4
	⅝	0	8·3		5¼	4	5·7		9⅞	8	3·1
	¾	0	10·0		5⅜	4	7·3		10	8	4·8
	⅞	0	11·6		5½	4	9·0		10⅛	8	6·4
	1	0	13·2		5⅝	4	10·7		10¼	8	8·1
	1⅛	0	14·9		5¾	4	12·3		10⅜	8	9·7
	1¼	1	0·6		5⅞	4	14·0		10½	8	11·4
	1⅜	1	2·2		6	4	15·6		10⅝	8	13·1
	1½	1	3·9		6⅛	5	1·3		10¾	8	14·7
	1⅝	1	5·5		6¼	5	3·0		10⅞	9	0·4
	1¾	1	7·2		6⅜	5	4·6		11	9	2·0
	1⅞	1	9·0		6½	5	6·3		11⅛	9	3·7
	2	1	10·5		6⅝	5	7·9		11¼	9	5·4
	2⅛	1	12·2		6¾	5	9·6		11⅜	9	7·0
	2¼	1	13·8		6⅞	5	11·3		11½	9	8·7
	2⅜	1	15·5		7	5	13·0		11⅝	9	10·3
	2½	2	1·2		7⅛	5	14·6		11¾	9	12·0
	2⅝	2	2·8		7¼	6	0·2		11⅞	9	13·7
	2¾	2	4·5		7⅜	6	2·0		12	9	15·3
	2⅞	2	6·1		7½	6	3·6				
	3	2	7·8		7⅝	6	5·2	⅜	¾	0	14·9
	3⅛	2	9·5		7¾	6	7·0		⅞	1	1·3
	3¼	2	11·1		7⅞	6	8·5		1	1	3·8
	3⅜	2	12·8		8	6	10·2		1⅛	1	6·3
	3½	2	14·4		8⅛	6	12·0		1¼	1	8·8
	3⅝	3	0·1		8¼	6	13·5		1⅜	1	11·3
	3¾	3	1·8		8⅜	6	15·2		1½	1	13·8
	3⅞	3	3·4		8½	7	0·8		1⅝	2	0·3

2	2	7·7	6⅝	8	3·6		11¼	1
2⅛	2	10·2	6¾	8	6·1		11⅜	1
2¼	2	12·7	6⅞	8	8·6		11½	1
2⅜	2	15·1	7	8	11·1		11⅝	1
2½	3	1·6	7⅛	8	13·5		11¾	1
2⅝	3	4·1	7¼	9	0·0		11⅞	1
2¾	3	6·6	7⅜	9	2·5		12	1
2⅞	3	9·1	7½	9	5·0			
3	3	11·6	7⅝	9	7·5	⅛	1	
3⅛	3	14·1	7¾	9	10·0		1⅛	
3¼	4	0·5	7⅞	9	12·4		1¼	
3⅜	4	3·0	8	9	14·9		1⅜	
3½	4	5·5	8⅛	10	1·4		1½	
3⅝	4	8·0	8¼	10	3·9		1⅝	
3¾	4	10·5	8⅜	10	6·4		1¾	
3⅞	4	13·0	8½	10	8·9		1⅞	
4	4	15·4	8⅝	10	11·3		2	
4⅛	5	1·9	8¾	10	13·8		2⅛	
4¼	5	4·4	8⅞	11	0·3		2¼	
4⅜	5	6·9	9	11	2·8		2⅜	
4½	5	9·4	9⅛	11	5·3		2½	
4⅝	5	11·9	9¼	11	7·8		2⅝	
4¾	5	14·3	9⅜	11	10·3		2¾	
4⅞	6	0·8	9½	11	12·7		2⅞	
5	6	3·3	9⅝	11	15·2		3	
5⅛	6	5·8	9¾	12	1·7		3⅛	

Thick.	Broad.	lbs.	oz.	Thick.	Broad.	lbs.	oz.	Thick.	Broad.	lbs.	oz.
in.	in.			in.	in.			in.	in.		
½	4⅜	7	3·9	½	9	14	14·4	⅝	2⅝	5	6·9
	4½	7	7·2		9⅛	15	1·7		2¾	5	11·0
	4⅝	7	10·5		9¼	15	5·0		2⅞	5	15·2
	4¾	7	13·8		9⅜	15	8·4		3	6	3·3
	4⅞	8	1·1		9½	15	11·7		3⅛	6	7·5
	5	8	4·4		9⅝	15	15·0		3¼	6	11·6
	5⅛	8	7·7		9¾	16	2·3		3⅜	6	15·7
	5¼	8	11·1		9⅞	16	5·6		3½	7	3·9
	5⅜	8	14·4		10	16	8·9		3⅝	7	8·0
	5½	9	1·7		10⅛	16	12·2		3¾	7	12·2
	5⅝	9	5·0		10¼	16	15·5		3⅞	8	0·3
	5¾	9	8·3		10⅜	17	2·8		4	8	4·4
	5⅞	9	11·6		10½	17	6·2		4⅛	8	8·6
	6	9	14·9		10⅝	17	9·5		4¼	8	12·7
	6⅛	10	2·2		10¾	17	12·8		4⅜	9	0·9
	6¼	10	5·6		10⅞	18	0·1		4½	9	5·0
	6⅜	10	8·9		11	18	3·4		4⅝	9	9·1
	6½	10	12·2		11⅛	18	6·7		4¾	9	13·3
	6⅝	10	15·5		11¼	18	10·0		4⅞	10	1·4
	6¾	11	2·8		11⅜	18	13·3		5	10	5·6
	6⅞	11	6·1		11½	19	0·7		5⅛	10	9·7
	7	11	9·4		11⅝	19	4·0		5¼	10	13·8
	7⅛	11	12·7		11¾	19	7·3		5⅜	11	2·0
	7¼	12	0·0		11⅞	19	10·6		5½	11	6·1
	7⅜	12	3·4		12	19	13·9		5⅝	11	10·3
	7½	12	6·7						5¾	11	14·4
	7⅝	12	10·0	⅝	1¼	2	9·4		5⅞	12	2·5
	7¾	12	13·3		1⅜	2	13·5		6	12	6·7
	7⅞	13	0·6		1½	3	1·6		6⅛	12	10·8
	8	13	3·9		1⅝	3	5·8		6¼	12	15·0
	8⅛	13	7·2		1¾	3	9·9		6⅜	13	3·1
	8¼	13	10·5		1⅞	3	14·1		6½	13	7·2
	8⅜	13	13·9		2	4	2·2		6⅝	13	11·4
	8½	14	1·2		2⅛	4	6·3		6¾	13	15·5
	8⅝	14	4·5		2¼	4	10·5		6⅞	14	3·7
	8¾	14	7·8		2⅜	4	14·6		7	14	7·8
	8⅞	14	11·1		2½	5	2·8		7⅛	14	11·9

7⅝	15	12·5		¾	1½	3	11·6		6⅛	15
7¾	16	0·6			1⅝	4	0·5		6¼	15
7⅞	16	4·8			1¾	4	5·5		6⅜	15
8	16	8·9			1⅞	4	10·5		6½	16
8⅛	16	13·1			2	4	15·4		6⅝	16
8¼	17	1·2			2⅛	5	4·4		6¾	16
8⅜	17	5·3			2¼	5	9·4		6⅞	17
8½	17	9·5			2⅜	5	14·3		7	17
8⅝	17	13·6			2½	6	3·3		7⅛	17
8¾	18	1·8			2⅝	6	8·3		7¼	18
8⅞	18	5·9			2¾	6	13·2		7⅜	18
9	18	10·0			2⅞	7	2·2		7½	18
9⅛	18	14·2			3	7	7·2		7⅝	18
9¼	19	2·3			3⅛	7	12·2		7¾	19
9⅜	19	6·5			3¼	8	1·1		7⅞	19
9½	19	10·6			3⅜	8	6·1		8	19
9⅝	19	14·7			3½	8	11·1		8⅛	20
9¾	20	2·9			3⅝	9	0·0		8¼	20
9⅞	20	7·0			3¾	9	5·0		8⅜	20
0	20	11·2			3⅞	9	10·0		8½	21
0⅛	20	15·3			4	9	14·9		8⅝	21
0¼	21	3·4			4⅛	10	3·9		8¾	21
0⅜	21	7·6			4¼	10	8·9		8⅞	22
0½	21	11·7			4⅜	10	13·8		9	22
0⅝	21	15·9			4½	11	2·8		9⅛	22
0¾	22	4·0			4⅝	11	7·8		9¼	22

Thick.	Broad.	qrs.	lbs.	oz.	Thick.	Broad.	lbs.	oz.	Thick.	Broad.	qrs.	lbs.	oz.
in.	in.				in.	in.			in.	in.			
¾	10⅜	0	25	12·3	⅞	4½	13	0·6	⅞	9⅛	0	26	7·1
	10½	0	26	1·3		4⅝	13	6·4		9¼	0	26	12·9
	10⅝	0	26	6·2		4¾	13	12·2		9⅜	0	27	2·7
	10¾	0	26	11·2		4⅞	14	2·0		9½	0	27	8·5
	10⅞	0	27	0·2		5	14	7·8		9⅝	0	27	14·3
	11	0	27	5·1		5⅛	14	13·6		9¾	1	0	4·0
	11⅛	0	27	10·1		5¼	15	3·4		9⅞	1	0	9·8
	11¼	0	27	15·1		5⅜	15	9·2		10	1	0	15·6
	11⅜	1	0	4·0		5½	15	15·0		10⅛	1	1	5·4
	11½	1	0	9·0		5⅝	16	4·8		10¼	1	1	11·2
	11⅝	1	0	14·0		5¾	16	10·6		10⅜	1	2	1·0
	11¾	1	1	3·0		5⅞	17	0·4		10½	1	2	6·8
	11⅞	1	1	7·9		6	17	6·2		10⅝	1	2	12·6
	12	1	1	12·9		6⅛	17	12·0		10¾	1	3	2·4
						6¼	18	1·8		10⅞	1	3	8·2
⅞	1¾	0	5	1·1		6⅜	18	7·6		11	1	3	14·0
	1⅞	0	5	6·9		6½	18	13·4		11⅛	1	4	3·8
	2	0	5	12·7		6⅝	19	3·1		11¼	1	4	9·6
	2⅛	0	6	2·5		6¾	19	8·9		11⅜	1	4	15·4
	2¼	0	6	8·3		6⅞	19	14·7		11½	1	5	5·2
	2⅜	0	6	14·1		7	20	4·5		11⅝	1	5	11·0
	2½	0	7	3·9		7⅛	20	10·3		11¾	1	6	0·8
	2⅝	0	7	9·7		7¼	21	0·1		11⅞	1	6	6·6
	2¾	0	7	15·5		7⅜	21	5·9		12	1	6	12·4
	2⅞	0	8	5·3		7½	21	11·7					
	3	0	8	11·1		7⅝	22	1·5	1	2	0	6	10·0
	3⅛	0	9	0·9		7¾	22	7·3		2⅛	0	7	0·6
	3¼	0	9	6·7		7⅞	22	13·1		2¼	0	7	7·2
	3⅜	0	9	12·4		8	23	2·9		2⅜	0	7	13·8
	3½	0	10	2·2		8⅛	23	8·7		2½	0	8	4·4
	3⅝	0	10	8·0		8¼	23	14·5		2⅝	0	8	11·1
	3¾	0	10	13·8		8⅜	24	4·3		2¾	0	9	1·7
	3⅞	0	11	3·6		8½	24	10·1		2⅞	0	9	8·3
	4	0	11	9·4		8⅝	24	15·9		3	0	9	14·7
	4⅛	0	11	15·2		8¾	25	5·7		3⅛	0	10	5·6
	4¼	0	12	5·0		8⅞	25	11·5		3¼	0	10	12·2
	4⅜	0	12	10·8		9	26	1·3		3⅜	0	11	2·8

3¾	12	6·7	6⅝	0	21	15·0	9½	1
3⅞	12	13·3	6¾	0	22	5·7	9⅝	1
4	13	3·9	6⅞	0	22	12·3	9¾	1
4⅛	13	10·6	7	0	23	2·9	9⅞	1
4¼	14	1·2	7⅛	0	23	9·5	10	1
4⅜	14	7·8	7¼	0	24	0·2	10⅛	1
4½	14	14·4	7⅜	0	24	6·6	10¼	1
4⅝	15	5·0	7½	0	24	13·4	10⅜	1
4¾	15	11·7	7⅝	0	25	4·0	10½	1
4⅞	16	2·3	7¾	0	25	10·6	10⅝	1
5	16	8·9	7⅞	0	26	1·3	10¾	1
5⅛	16	15·5	8	0	26	7·9	10⅞	1
5¼	17	6·2	8⅛	0	26	14·5	11	1
5⅜	17	12·8	8¼	0	27	5·1	11⅛	1
5½	18	3·4	8⅜	0	27	11·8	11¼	1
5⅝	18	10·0	8½	1	0	2·4	11⅜	1
5¾	19	0·7	8⅝	1	0	9·0	11½	1
5⅞	19	7·3	8¾	1	0	15·6	11⅝	1
6	19	13·9	8⅞	1	1	6·3	11¾	1
6⅛	20	4·5	9	1	1	12·9	11⅞	1
6¼	20	11·2	9⅛	1	2	3·5	12	1

Thick.	Broad.	qrs.	lbs.	oz.
in.	in.			
1⅛	2¼	0	8	6·1
	2½	0	9	5·0
	2¾	0	10	3·9
	3	0	11	2·8
	3¼	0	12	1·7
	3½	0	13	0·6
	3¾	0	13	15·5
	4	0	14	14·4
	4¼	0	15	13·3
	4½	0	16	12·2
	4¾	0	17	11·1
	5	0	18	10·0
	5¼	0	19	8·9
	5½	0	20	7·8
	5¾	0	21	6·8
	6	0	22	5·7
	6¼	0	23	4·6
	6½	0	24	3·5
	6¾	0	25	2·4
	7	0	26	1·3
	7¼	0	27	0·2
	7½	0	27	15·1
	7¾	1	0	14·0
	8	1	1	12·9
	8¼	1	2	11·8
	8½	1	3	10·7
	8¾	1	4	9·6
	9	1	5	8·5
	9¼	1	6	7·4
	9½	1	7	6·3
	9¾	1	8	5·2
	10	1	9	4·1
	10¼	1	10	3·0
	10½	1	11	1·9
	10¾	1	12	0·8
	11	1	12	15·7
	11¼	1	13	14·6

Thick.	Broad.	qrs.	lbs.	oz.
in.	in.			
1⅛	11½	1	14	13·5
	11¾	1	15	12·4
	12	1	16	11·4
1¼	2½	0	10	5·6
	2¾	0	11	6·1
	3	0	12	6·7
	3¼	0	13	7·2
	3½	0	14	7·8
	3¾	0	15	8·4
	4	0	16	8·9
	4¼	0	17	9·5
	4½	0	18	10·0
	4¾	0	19	10·6
	5	0	20	11·2
	5¼	0	21	11·7
	5½	0	22	12·3
	5¾	0	23	12·8
	6	0	24	13·4
	6¼	0	25	14·0
	6½	0	26	14·5
	6¾	0	27	15·1
	7	1	0	15·6
	7¼	1	2	0·2
	7½	1	3	0·8
	7¾	1	4	1·3
	8	1	5	1·9
	8¼	1	6	2·4
	8½	1	7	3·0
	8¾	1	8	3·6
	9	1	9	4·1
	9¼	1	10	4·7
	9½	1	11	5·2
	9¾	1	12	5·8
	10	1	13	6·4
	10¼	1	14	6·9
	10½	1	15	7·5

Thick.	Broad.	qrs.	lbs.	oz.
in.	in.			
1¼	10¾	1	16	8·0
	11	1	17	8·6
	11¼	1	18	9·2
	11½	1	19	9·7
	11¾	1	20	10·3
	12	1	21	10·8
1⅜	2¾	0	12	8·3
	3	0	13	10·6
	3¼	0	14	12·8
	3½	0	15	15·0
	3¾	0	17	1·2
	4	0	18	3·4
	4¼	0	19	5·6
	4½	0	20	7·8
	4¾	0	21	10·1
	5	0	22	12·3
	5¼	0	23	14·5
	5½	0	25	0·7
	5¾	0	26	2·9
	6	0	27	5·1
	6¼	1	0	7·4
	6½	1	1	9·6
	6¾	1	2	11·8
	7	1	3	14·0
	7¼	1	5	0·2
	7½	1	6	2·4
	7¾	1	7	4·7
	8	1	8	6·9
	8¼	1	9	9·1
	8½	1	10	11·3
	8¾	1	11	13·5
	9	1	12	15·7
	9¼	1	14	2·0
	9½	1	15	4·2
	9¾	1	16	6·4
	10	1	17	8·6

	5¾	1	14	13·5
	6	1	16	11·4
	6¼	1	18	9·2
	6½	1	20	7·0
	6¾	1	22	4·8
	7	1	24	2·6
	7¼	1	26	0·4
	7½	1	27	14·2
	7¾	2	1	12·0
	8	2	3	9·8
	8¼	2	5	7·6
	8½	2	7	5·4
	8¾	2	9	3·2
	9	2	11	1·0
	9¼	2	12	14·9
	9½	2	14	12·7
	9¾	2	16	10·5
	10	2	18	8·3
	10¼	2	20	6·1
	10½	2	22	3·9
	10¾	2	24	1·7
	11	2	25	15·5
	11¼	2	27	13·3
	11½	3	1	11·1
	11¾	3	3	8·9
	12	3	5	6·7
[illegible]	4¾	1	9	5·8
	5	1	11	5·2
	[illegible]	[illegible]	[illegible]	4·7

	7¼	2	1	0·4
	7½	2	2	15·9
	7¾	2	4	15·3
	8	2	6	14·8
	8¼	2	8	14·3
	8½	2	10	13·7
	8¾	2	12	13·2
	9	2	14	12·7
	9¼	2	16	12·1
	9½	2	18	11·6
	9¾	2	20	11·1
	10	2	22	10·5
	10¼	2	24	10·0
	10½	2	26	9·4
	10¾	3	0	8·9
	11	3	2	8·4
	11¼	3	4	7·8
	11½	3	6	7·3
	11¾	3	8	6·8
	12	3	10	6·2
2⅛	5	1	13	6·4
	5¼	1	15	7·5
	5½	1	17	8·6
	5¾	1	19	9·7
	6	1	21	10·8
	6¼	1	23	12·0
	6½	1	25	13·1
	6¾	1	27	14·2
	7	2	1	15·3

	9
	9¼
	9½
	9¾
	10
	10¼
	10½
	10¾
	11
	11¼
	11½
	11¾
	12
2⅝	5¼
	5½
	5¾
	6
	6¼
	6½
	6¾
	7
	7¼
	7½
	7¾
	8
	8¼
	8½
	8¾
	9

respective thickness of each bar. Hence u
of any length of a bar of rectangular iro
ascertained simply, as follows :

Rule.—Multiply the tabular weight, acc
the thickness and breadth, by the number
the bar, the product will be the weight requ

Example.—In a bar of iron whose thickn
inches, the breadth 6¾ inches, and the lengt
what is the weight thereof?

In the Table for 2⅝ inches thick, and op
inches, stand 2qrs. 2lbs. 10·9oz., being t
of one lineal foot. Multiply this number b
and we have as follows :

cwt.	qrs.	lbs.	oz.	
0	2	2	10·9	
				6 × 3 = 18
3	0	16	1·4	
			3	
9	1	20	4·2	Answer.

The foregoing Table of weights is obtai
following approximate rule :

Multiply the area of the end of the
length of one foot, and multiply that produ
the product will be the weight in pounds

Inches	qrs.	lbs.	oz.	Inches	qrs.	lbs.	oz.	Inches	qrs.	lbs.
⅛	0	0	0·4	4⅛	1	16	4·1	8⅛	6	3
¼	0	0	2·6	4¼	1	18	15·8	8¼	6	8
⅜	0	0	5·8	4⅜	1	21	12·6	8⅜	6	14
½	0	0	10·4	4½	1	24	10·8	8½	6	19
⅝	0	1	0·1	4⅝	1	27	10·2	8⅝	6	25
¾	0	1	7·3	4¾	2	2	11·0	8¾	7	3
⅞	0	1	15·8	4⅞	2	5	13·1	8⅞	7	8
1	0	2	9·4	5	2	9	0·6	9	7	14
1⅛	0	3	4·8	5⅛	2	12	5·2	9⅛	7	20
1¼	0	4	1·1	5¼	2	15	11·0	9¼	7	26
1⅜	0	4	14·7	5⅜	2	19	2·4	9⅜	8	4
1½	0	5	13·7	5½	2	22	11·0	9½	8	[illegible]
1⅝	0	6	13·9	5⅝	2	26	4·8	9⅝	8	[illegible]
1¾	0	7	15·5	5¾	3	2	0·1	9¾	8	[illegible]
1⅞	0	9	2·4	5⅞	3	5	12·6	9⅞	9	[illegible]
2	0	10	6·5	6	3	9	10·4	10	9	[illegible]
2⅛	0	11	12·0	6⅛	3	13	8·6	10⅛	9	[illegible]
2¼	0	13	1·7	6¼	3	17	9·0	10¼	9	[illegible]
2⅜	0	14	10·7	6⅜	3	21	10·6	10⅜	9	[illegible]
2½	0	16	4·1	6½	3	25	13·6	10½	10	[illegible]
2⅝	0	17	14·8	6⅝	4	2	1·8	10⅝	10	[illegible]
2¾	0	19	9·6	6¾	4	6	7·4	10¾	10	[illegible]
2⅞	0	21	8·0	6⅞	4	11	1·4	10⅞	10	[illegible]
3	0	23	6·5	7	4	15	6·4	11	11	[illegible]
3⅛	0	25	6·4	7⅛	4	19	15·5	11⅛	11	[illegible]
3¼	0	27	7·6	7¼	4	24	10·6	11¼	11	[illegible]
3⅜	1	1	10·0	7⅜	5	1	6·7	11⅜	12	[illegible]
3½	1	3	13·9	7½	5	6	4·0	11½	12	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11⅝	12	[illegible]

The Tables of the weight of round and squ
' malleable iron have been obtained by the f
ıproximate rules :

Rule 1.—For round bars. Multiply the s
ıe diameter in inches by the length in feet,
roduct by 2·6. The product will be the w
ɔunds avoirdupois, nearly.

Rule 2.—For square bars. Multiply the
ıe end of the bar in inches by the length
ıd that by 3·32. The product will be th
ı pounds avoirdupois, nearly.

Example 1.—What is the weight of a roun
ıalleable iron $4\frac{1}{2}$ feet long, and $2\frac{1}{4}$ inches
ıeter?

$2{\cdot}25^2 \times 4{\cdot}5 = 22{\cdot}78125 \times 2{\cdot}6 = 59{\cdot}23125$ lbs. $= 59$ lbs

Example 2.—Required the weight of a sq
f malleable iron whose length is $7\frac{1}{4}$ feet,
ıch square.

$1{\cdot}5^2 \times 7{\cdot}25 = 16{\cdot}3125 \times 3{\cdot}32 = 54{\cdot}1575$ lbs. $= 54$ lbs.

		1/2	5	5 7/8			[illegible]				
		5/8	5	6 1/4			5/8	6	8 7/8		
		3/4	5	6 5/8			3/4	6	9 1/4	3/4	8	0
		7/8	5	7			7/8	6	9 5/8	7/8	8	0
1	11		5	7 3/8	2	4		6	10	2	9		8	0
		1/8	5	7 3/4			1/8	6	10 3/8			1/8	8	1
		1/4	5	8 1/8			1/4	6	10 3/4			1/4	8	1
		3/8	5	8 1/2			3/8	6	11 1/8			3/8	8	1
		1/2	5	8 7/8			1/2	6	11 1/2			1/2	8	2
		5/8	5	9 1/4			5/8	6	11 7/8			5/8	8	2
		3/4	5	9 5/8			3/4	7	0 1/4			3/4	8	2
		7/8	5	9 7/8			7/8	7	0 5/8			7/8	8	3
2	0		5	10 1/4	2	5		7	1	2	10		8	3
		1/8	5	10 5/8			1/8	7	1 3/8			1/8	8	
		1/4	5	11			1/4	7	1 3/4			1/4	8	
		3/8	5	11 3/8			3/8	7	2			3/8	8	
		1/2	5	11 3/4			1/2	7	2 3/8			1/2	8	
		5/8	6	0 1/8			5/8	7	2 3/4			5/8	8	
		3/4	6	0 1/2			3/4	7	3 1/8			3/4	8	
		7/8	6	0 7/8			7/8	7	3 1/2			7/8	8	
2	1		6	1 1/4	2	6		7	3 7/8	2	11		8	
		1/8	6	1 5/8			1/8	7	4 1/4			1/8	[illegible]	
		1/4	6	2			1/4	7	4 5/8			1/4		
		3/8	6	2 3/8			3/8	7	5			3/8		
		1/2	6	2 3/4			1/2	7	5 3/8			1/2		
		5/8	6	3			5/8	7	5 3/4			5/8		
		3/4	6	3 3/8			3/4	7	6 1/8			3/4		
				[illegible]			7/8	7	6 1/2			7/8		

	$\frac{3}{4}$	15	$3\frac{7}{8}$		$\frac{3}{4}$	16	$0\frac{5}{8}$		$\frac{3}{4}$	[illegible]	[illegible]
	$\frac{7}{8}$	15	$4\frac{1}{4}$		$\frac{7}{8}$	16	1		$\frac{7}{8}$	16	$9\frac{7}{8}$
5	3	15	$4\frac{5}{8}$	5	6	16	$1\frac{3}{8}$	5	9	16	$10\frac{1}{4}$
	$\frac{1}{8}$	15	5		$\frac{1}{8}$	16	$1\frac{3}{4}$		$\frac{1}{8}$	16	$10\frac{1}{2}$
	$\frac{1}{4}$	15	$5\frac{3}{8}$		$\frac{1}{4}$	16	$2\frac{1}{8}$		$\frac{1}{4}$	16	$10\frac{7}{8}$
	$\frac{3}{8}$	15	$5\frac{3}{4}$		$\frac{3}{8}$	16	$2\frac{1}{2}$		$\frac{3}{8}$	16	$11\frac{1}{4}$
	$\frac{1}{2}$	15	$6\frac{1}{8}$		$\frac{1}{2}$	16	$2\frac{7}{8}$		$\frac{1}{2}$	16	$11\frac{5}{8}$
	$\frac{5}{8}$	15	$6\frac{1}{2}$		$\frac{5}{8}$	16	$3\frac{1}{4}$		$\frac{5}{8}$	17	0
	$\frac{3}{4}$	15	$6\frac{7}{8}$		$\frac{3}{4}$	16	$3\frac{5}{8}$		$\frac{3}{4}$	17	0[illegible]
	$\frac{7}{8}$	15	$7\frac{1}{8}$		$\frac{7}{8}$	16	4		$\frac{7}{8}$	17	0[illegible]
5	4	15	$7\frac{1}{2}$	5	7	16	$4\frac{3}{8}$				
	$\frac{1}{8}$	15	$7\frac{7}{8}$		$\frac{1}{8}$	16	$4\frac{3}{4}$				
	$\frac{1}{4}$	15	$8\frac{1}{4}$		$\frac{1}{4}$	16	$5\frac{1}{8}$				
	$\frac{3}{8}$	15	$8\frac{5}{8}$		$\frac{3}{8}$	16	$5\frac{3}{8}$				
	$\frac{1}{2}$	15	9		$\frac{1}{2}$	16	$5\frac{3}{4}$				
	$\frac{5}{8}$	15	$9\frac{3}{8}$		$\frac{5}{8}$	16	$6\frac{1}{8}$				
	$\frac{3}{4}$	15	$9\frac{3}{4}$		$\frac{3}{4}$	16	$6\frac{1}{2}$				
	$\frac{7}{8}$	15	$10\frac{1}{8}$		$\frac{7}{8}$	16	$6\frac{7}{8}$				

	⅝	12	1⅞		⅝	[illegible]	[illegible]				
	¾	12	2⅜		¾	13	7½		¾	15	0[illegible]
	⅞	12	2¾		⅞	13	7⅞		⅞	15	1
	7	12	3¼	4	0	13	8⅜	4	5	15	1½
	⅛	12	3⅝		⅛	13	8¾		⅛	15	1⅞
	¼	12	4⅛		¼	13	9¼		¼	15	2¼
	⅜	12	4½		⅜	13	9⅝		⅜	15	2¾
	½	12	4⅞		½	13	10		½	15	3⅛
	⅝	12	5⅜		⅝	13	10½		⅝	15	3⅝
	¾	12	5¾		¾	13	10⅞		¾	15	4
	⅞	12	6¼		⅞	13	11⅜		⅞	15	4½
3	8	12	6⅝	4	1	13	11¾	4	6	15	4⅞
	⅛	12	7		⅛	14	0¼		⅛	15	5¼
	¼	12	7½		¼	14	0⅝		¼	15	5¾
	⅜	12	7⅞		⅜	14	1		⅜	15	6[illegible]
	½	12	8⅜		½	14	1½		½	15	6[illegible]
	⅝	12	8¾		⅝	14	1⅞		⅝	15	7
	¾	12	9¼		¾	14	2⅜		¾	15	7[illegible]
	⅞	12	9⅝		⅞	14	2¾		⅞	15	7[illegible]
3	9	12	10	4	2	14	3⅛	4	7	15	8[illegible]
	⅛	12	10½		⅛	14	3½		⅛	15	[illegible]
	¼	12	10⅞		¼	14	4		¼	15	[illegible]
	⅜	12	11⅜		⅜	14	4½		⅜	15	[illegible]
	½	12	11¾		½	14	4⅞		½	15	1[illegible]
	⅝	13	0¼		⅝	14	5⅜		⅝	15	1[illegible]
	¾	13	0⅝		¾	14	5¾		¾	15	1[illegible]
	⅞	13	1		⅞	14	6⅛		⅞	15	1[illegible]

breadth of the angle must be taken from
meter,—for this reason, that the diamete
from outside to outside of the ring, as in t
ing sectional figure:

Suppose a ring is to be made of ar
whose diameter outside is to be 12 in
breadth of the angle 2½ inches; then, by
inches from 12 inches, we have left 9
Looking into the Table in the column of d
find in the circumference column, opposite
2 feet 8½ inches, which is the length of i
sary for the ring.

It has been already observed, that betw
and plain iron a considerable difference
regard to the proportion of the circumfer
diameter: this is owing to the angle or fla
side of the bar, and when the iron is fo
hoop it contracts more or less, as th
f... be inside or outside of the hc

Ex. Required the circumference of a hoop, whose axes are $18\frac{1}{2}$ and 13 inches, ness of the iron being $2\frac{1}{2}$ inches. (*Table*

$$\begin{array}{r l} & 18\frac{1}{2} \\ & 13 \\ \hline 2) & 31\frac{1}{2} \\ \hline & 15\frac{3}{4} \\ + & 2\frac{1}{2} \text{ thickness.} \\ \hline & 18\frac{1}{4} \text{ inches, the diameter.} \end{array}$$

Entering into the Table of Diamet inches, the circumference will be found $9\frac{1}{4}$ inches.

In constructing elliptical hoops of with the angle outside, reference must the Tables for hoops of angled iron: will be similar to the above example. where the angle is inside, the thicknes must be taken from half the sum of the

Note.—It must be observed, that in given in the Observations on Table I., hoops formed of angled iron, that t ferences are nothing more than the enc

unit being that of a common sheet, so desig
, 4 feet by 2 feet, in lbs.; thus,

A 70lb plate is	$\frac{3}{16}$ths	of an inch in thickness.	
46½	"	$\frac{1}{8}$	"
23	"	$\frac{1}{16}$	"
11½	"	$\frac{1}{32}$	"
6	"	$\frac{1}{64}$ &c., &c.	

The thickness of lead is also in common dete
understood by the weight, the unit being th
iare or superficial foot; thus,

4-lb lead is	$\frac{1}{16}$th	of an inch in thickness.	
6	"	$\frac{1}{10}$	"
7½	"	$\frac{1}{8}$	"
11	"	$\frac{3}{16}$	"
15	"	$\frac{1}{4}$	"

MPARATIVE WEIGHTS OF DIFFERENT B

Bar iron being 1.		Cast iron being 1.		Dry deal be	
Cast iron	= ·95	Bar iron	=1·07	Cast iron	=
Steel	=1·02	Steel	=1·08	Cast tin	=
Copper	=1·16	Brass	=1·16	Brass	=
Brass	=1·09	Copper	=1·21	Copper	=
Lead	=1·48	Lead	=1·56	Lead	=

1. Suppose I have an article of plate iron, th

Thickness in parts of an inch.	Wrought iron.	Copper.		Lead.
$\frac{1}{32}$	·326	$11\frac{1}{2}$ lbs. plate	·38	2 lbs. lead
$\frac{1}{16}$	·653	$23\frac{1}{2}$ "	·76	4 "
$\frac{3}{32}$	·976	35 "	1·14	$5\frac{1}{2}$ "
$\frac{1}{8}$	1·3	$46\frac{1}{2}$ "	1·52	8 "
$\frac{5}{32}$	1·627	58 "	1·9	$9\frac{1}{4}$ "
$\frac{3}{16}$	1·95	70 "	2·28	11 "
$\frac{7}{32}$	2·277	$80\frac{1}{2}$ "	2·66	13 "
$\frac{1}{4}$	2·6	93 "	3·04	15 "

Rule.—To the interior diameter of the p inches, add the thickness of the metal; multi sum by the decimal numbers opposite the r thickness and under the metal's name; also length of the pipe in feet, and the product weight of the pipe in lbs.

1. Required the weight of a copper pipe w terior diameter is $7\frac{1}{4}$ inches, its length $6\frac{1}{4}$ fe the metal $\frac{1}{8}$ of an inch in thickness.

$$7·5 + ·125 = 7·625 \times 1·52 \times 6·25 = 72·4 \text{ lbs.}$$

2. What is the weight of a leaden pipe $18\frac{1}{2}$

BLES BY WHICH ...

TION OF TIMBER.

1. *Flat or Board Measure.*

Breadth in inches.	Area of a lineal foot.	Breadth in inches.	Area of a lineal foot.	Breadth in inches.	Area lineal
¼	·0208	4	·3334	8	·6
½	·0417	4¼	·3542	8¼	·6
¾	·0625	4½	·375	8½	·7
1	·0834	4¾	·3958	8¾	·7
1¼	·1042	5	·4167	9	·7
1½	·125	5¼	·4375	9¼	·7
1¾	·1459	5½	·4583	9½	·7
2	·1667	5¾	·4792	9¾	·8
2¼	·1875	6	·5	10	·8
2½	·2084	6¼	·5208	10¼	·8
2¾	·2292	6½	·5416	10½	·8
3	·25	6¾	·5625	10¾	·8
3¼	·2708	7	·5833	11	·9
3½	·2916	7¼	·6042	11¼	·9
3¾	·3125	7½	·625	11½	·9
		7¾	·6458	11¾	·9

Application and Use of the Table.

1. Required the number of square feet in a
or plank 16½ feet in length and 9¾ inches in br

Opposite 9¾ is ·8125 × 16·5 = 13·4 square feet.

... inches in breadth and

en dimensions —

Suppose the mean $\frac{1}{4}$ girt of a tree 21$\frac{1}{4}$ i l its length 16 feet, what are its contents in t?

8·136 × 16=50·176 cubic feet.

Battens, Deals, and Planks, as imported int untry, are each similar in their various lengtl ffering in their widths and thicknesses, and ieir principal distinction: thus, a batten is 7 y 2½,—a deal 9 by 3,—and a plank 11 by 3,– eing what are termed the standard dimensic hich they are bought and sold, the length o eing taken at 12 feet; therefore, in estimat he proper value of any quantity, nothing mor quired than their lineal dimensions, by which t tain the number of times 12 feet there are in tl whole.

Suppose I wish to purchase the following:

7 of	6 feet	6 × 7= 42	feet
5 „	14 „	14 × 5= 70	„
11 „	19 „	19 × 11=209	„
and 6 „	21 „	21 × 6=126	„

12)447(37·25 standard

2. Suppose I pay 31*s.* 6*d.* for three cwt oı ı what rate is that per ton? 1 *ton*=20 *cwt.*

Set 3 upon B to 31·5 upon A; and against 20 upon ı upon A.

RULE OF THREE INVERSE.

Rule.—Invert the slide, and the operation same as direct proportion.

1. I know that six men are capable of perf a certain given portion of work in eight days want the same performed in three; how maı must there be employed?

Set 6 upon C to 8 upon A; and against 3 upon C is 16

2. The lever of a safety-valve is 20 inches in and 5 inches between the fixed end and centr valve; what weight must there be placed on of the lever to equipoise a force or pressure of tending to raise the valve?

Set 5 upon C to 40 upon A; and against 20 on C is 1

3. If $8\frac{3}{4}$ yards of cloth, $1\frac{1}{2}$ yard in widt sufficient quantity, how much will be required which is only $\frac{7}{8}$ths in width, to effect the sar

lbs. on c.

1. Required the cubic contents of a ... length, and 10 inches quarter girt.

Set 30 upon B to 144 (the gauge-point) upon A ... 10 upon D is 20·75 feet upon C.

2. In a cylinder 9 inches in length, a... diameter, how many cubic inches?

Set 9 upon B to 1273 (the gauge-point) upon A ... 7 on D is 346 inches on C.

3. What is the weight of a bar of cast i... square, and 6 feet long?

Set 6 upon B to 32 (the gauge-point) upon A; ... upon D is 168 lbs. upon C.

By the common rule.

4. Required the weight of a cylinder ... iron 10 inches long, and 5½ diameter.

Set 10 upon B to 283 (G. P^{t}.) upon A; and ... D is 66·65 lbs. on C.

5. What is the weight of a dry rope ... and 4 inches circumference?

Set 25 upon B to 47 (G. P^{t}.) upon A; and ... 53·16 lbs. on C.

6. What is the weight of a short-li...

23 feet in length and 5½ in width?

Set 1 upon B to 23 upon A; and against 126·5 square feet upon A.

If 5 square feet of boiler surface be each horse-power, how many horses' po is the boiler equal to?

Set 5 upon B to 126·5 upon A; and agai 25·5 upon A.

[illegible]n lbs.		cwt. or 112 lbs.			qr. or 28 lbs.			stone or 14 lbs.		lb. or 1.	doz. or 12.		score or 20.		per 100.			per 12[illegible]	
S.	D.	L.	S.	D.	L.	S.	D.	S.	D.	D.	S.	D.	S.	D.	L.	S.	D.	L.	S.
[illegible]	8	0	2	4	0	0	7	0	3½	¼	0	3	0	5	0	2	1	0	2
[illegible]	0	0	3	6	0	0	10½	0	5¼	⅜	0	4½	0	7½	0	3	1½	0	3
[illegible]	4	0	4	8	0	1	2	0	7	½	0	6	0	10	0	4	2	0	5
[illegible]	8	0	5	10	0	1	5½	0	8¾	⅝	0	7½	1	0½	0	5	2½	0	6
0	0	0	7	0	0	1	9	0	10½	¾	0	9	1	3	0	6	3	0	7
3	4	0	8	2	0	2	0½	1	0¼	⅞	0	10½	1	5½	0	7	3½	0	8
6	8	0	9	4	0	2	4	1	2	1*d.*	1	0	1	8	0	8	4	0	10
10	0	0	10	6	0	2	7½	1	3¾	1⅛	1	1½	1	10½	0	9	4½	0	11
13	4	0	11	8	0	2	11	1	5½	1¼	1	3	2	1	0	10	5	0	12
16	8	0	12	10	0	3	2½	1	7¼	1⅜	1	4½	2	3½	0	11	5½	0	13
0	0	0	14	0	0	3	6	1	9	1½	1	6	2	6	0	12	6	0	15
3	4	0	15	2	0	3	9½	1	10¾	1⅝	1	7½	2	8½	0	13	6½	0	16
6	8	0	16	4	0	4	1	2	0½	1¾	1	9	2	11	0	14	7	0	17
10	0	0	17	6	0	4	4½	2	2¼	1⅞	1	10½	3	1½	0	15	7½	0	18
13	4	0	18	8	0	4	8	2	4	2*d.*	2	0	3	4	0	16	8	1	0
16	8	0	19	10	0	4	11½	2	5¾	2⅛	2	1½	3	6½	0	17	8½	1	1
0	0	1	1	0	0	5	3	2	7½	2¼	2	3	3	9	0	18	9	1	[illegible]
3	4	1	2	2	0	5	6½	2	9¼	2⅜	2	4½	3	11½	0	19	9½	1	[illegible]
6	8	1	3	4	0	5	10	2	11	2½	2	6	4	2	1	0	10	1	[illegible]
10	0	1	4	6	0	6	1½	3	0¾	2⅝	2	7½	4	4½	1	1	10½	1	
13	4	1	5	8	0	6	5	3	2½	2¾	2	9	4	7	1	2	11	1	
[illegible]	[illegible]	1	6	10	0	6	8½	3	4¼	2⅞	2	10½	4	9½	1	3	11½	1	
						[illegible]	[illegible]	3	6	3*d.*	3	0	5	0	1	5	0	1	[illegible]

500	"	=	16 2
50	"	=	1 12
2	"	=	0 1
2552			£82 8

2. In the Table of Equivalent Prices, the fi lumn from the left hand is the price per single or 1; hence the other columns on the right anc that give the price at an equal rate, according various denominations by which the columns are l

Thus, suppose the price per lb.$=3\frac{1}{4}d.$, the pi ton=£30. 6*s*. 8*d*. Again, suppose the price pe =£1. 10*s*., the price per dozen=2*s*. 6*d*., &c.

STRENGTH OF MATERIALS.

Materials of construction are liable to fo ferent kinds of strain; viz., stretching, cr transverse action, and torsion or twisting: t of which depends upon the body's tenacity the second, on its resistance to compression; th on its tenacity and compression combined; fourth, on that property by which it oppo acting force tending to change from a straig to that of a spiral direction, the fibres of wl

Circum in inch	Weigh thom i	Diame chain	Weigh fathom	tons & cwt.		Circu in inc	Weigh thom	Diam chain	Weig thom
3½	2¾	$\frac{5}{16}$	5½	1	5½	10	23	⅞	43
4¼	4¾	⅜	8	1	16¾	10¾	28	$\frac{15}{16}$	49
5	5¾	$\frac{7}{16}$	10½	2	10	11½	30½	1in.	56
5¾	7	½	14	3	5½	12¼	36	$1\frac{1}{16}$	63
6½	9¾	$\frac{9}{16}$	18	4	3½	13	39	1⅛	71
7	11¼	⅝	22	5	2	13¾	45	$1\frac{3}{16}$	79
8	15	$\frac{11}{16}$	27	6	4½	14½	48½	1¼	87
8¾	19	¾	32	7	7	15¼	56	$1\frac{5}{16}$	96
9½	21	$\frac{13}{16}$	37	8	13½	16	60	1⅜	106

Note.—It must be understood and also borne in n in estimating the amount of tensile strain to which subjected, the weight of the body itself must also into account; for according to its position so may i mate to its whole weight, in tending to produc within itself; as in the almost constant applicatioı and chains to great depths, considerable heights, &

Alloys that are of greater Tenacity than the their Constituents, as determined by the ments of Muschenbroek.

Swedish copper 6 parts, Malacca tin 1; tenacity per sq. inc
Chili copper 6 parts, Malacca tin 1; „ „
Japan copper 5 parts, Banca tin 1; „ „
Anglesea copper 6 parts, Cornish tin 1; „ „

beam in ...

Ex. A beam of Riga fir, 12 inches by ... jecting 6½ feet from the wall; what is tl weight it will support at the extremity of :

Tabular value of s=1100
12 × 4·5=54 sectional area.

$$\text{Then, } \frac{1100 \times 12 \times 54}{78} = 9138{\cdot}4 \text{ lbs.}$$

When fracture of a beam is produced pressure, the fibres of the lower section (are separated by extension, whilst at the those of the upper portion are destroye pression; hence exists a point in section wh the one nor the other takes place, and wl tinguished as the point of neutral axis. by the law of fracture thus established, data of tenacity and compression given Table (p. 137), we are enabled to form me strongest section with the least possible ma in cast iron the resistance to compressio 6½ to 1 of tenacity; consequently a beam c be of strongest section must be of the fol

and a parabola in the dir length, the quantity of ma bottom flange being about 6 ... but such is

3	1278	·24	1089	·33	954	·426	855
3½	1739	·205	1482	·28	1298	·365	1164
4	2272	·18	1936	·245	1700	·32	1520
4½	2875	·16	2450	·217	2146	·284	1924
5	3560	·144	3050	·196	2650	·256	2375
6	5112	·12	4356	·163	3816	·213	3420
7	6958	·103	5929	·14	5194	·183	4655
8	9088	·09	7744	·123	6784	·16	6080
9	—	—	9801	·109	8586	·142	7695
10	—	—	12100	098	10600	·128	9500
11	—	—	—	—	12826	·117	11495
12	—	—	—	—	15264	·107	13680
13	—	—	—	—	—	—	16100
14	—	—	—	—	—	—	18600
	12 feet.		**14 feet.**		**16 feet.**		**18 feet**
6	2548	·48	2184	·65	1912	·85	1699
7	3471	·41	2975	·58	2603	·73	2314
8	4532	·36	3884	·49	3396	·64	3020
9	5733	·32	4914	·44	4302	·57	3825
10	7083	·28	6071	·39	5312	·51	4722
11	8570	·26	7346	·36	6428	·47	5714
12	10192	·24	8736	·33	7648	·43	6796
13	11971	·22	10260	·31	8978	·39	7980
14	13883	·21	11900	·28	10412	·36	9255
15	15937	·19	13660	·26	11952	·34	10624
16	18128	·18	15536	·24	13584	·32	12080
17	20500	·17	17500	·23	15353	·3	13647
18	22932	·16	19656	·21	17208	·28	15700

lbs. by the square of the column's length
divide the product by twenty times the t
of E; and the quotient will be equal to
multiplied by the cube of the least thic
being expressed in inches.

Note 1.—When the pillar or support is a sc
will be the fourth root of the quotient.

2. If the pillar or column be a cylindar,
tabular value of E by 12, and the fourth root o
equal the diameter.

Ex. 1. What should be the least dime
oak support, to bear a weight of 2240
sensible flexure, its breadth being 3 in
length 5 feet?

Tabular value of E=105,

$$\text{and } \frac{2240 \times 5^2}{20 \times 105 \times 3} = \sqrt[3]{8 \cdot 888} = 2 \cdot 05$$

Ex. 2. Required the side of a square
fir, 9 feet in length, to bear a permane
6000 lbs.

Tabular value of E=96,

$$\text{and } \frac{6000 \times 9^2}{20 \times 96} = \sqrt[4]{253} = 4 \text{ inches}$$

" .. ..
" oak (Dantzic) "
" red deal "

Elasticity of torsion, or resistance of bodie

The angle of flexure by torsion is as and extensibility of the body directly, a as the diameter; hence, the length of a being given, the power, and the leverag acts with, being known, and also the nu grees of torsion that will not affect the machine, to determine the diameter in ca a given angle of flexure.

Rule.—Multiply the power in lbs. by the shaft in feet, and by the leverage in the product by fifty-five times the numb in the angle of torsion: and the fourth quotient equal the shaft's diameter in in

Ex. Required the diameters for a ser 35 feet in length, and to transmit a po 1245 lbs., acting at the circumference o feet radius, so that the twist of the shaf plication of the power may not exceed c

$$\frac{1245 \times 35 \times 2{\cdot}5}{55 \times 1} = \sqrt[4]{1981} = 6{\cdot}67 \text{ inches in}$$

Relative strength of metals to resist

surfaces.

Heat also expands water in the li
Thus, when water is at 42° Fahr., it is at
density, or 1·00000 in bulk.

At 62° Fahr.	its bulk	is increased to	1·
„ 92	„	„	1·
„ 122	„	„	1·
„ 152	„	„	1·
„ 182	„	„	1·
„ 212	„	„	1·

Water also expands in nearly an
from 42° Fahr., by reduction of temperat
abstraction of heat, down to the freezi

Atmospheric air is increased in bu
tion of temperature, as in the followin

At 32° Fahr.	vol.	equal	1·000	At 100°	Fahr.
„ 35	„	„	1·007	„ 110	„
„ 40	„	„	1·021	„ 120	„
„ 45	„	„	1·032	„ 130	„
„ 50	„	„	1·043	„ 140	„
„ 55	„	„	1·055	„ 150	„
„ 60	„	„	1·066	„ 160	„
„ 65	„	„	1·077	„ 170	„
„ 70	„	„	1·089	„ 180	„
„ 75	„	„	1·099	„ 190	„
„ 80	„	„	1·110	„ 200	„
			[illegible]	210	

conductors or retainers of heat, are
viz.:—Stones, bricks, earthenware,
sheep's wool, raw silk, and fur, eac
sively lower in their conducting powe

Specific heat (formerly, capacity
a term applied to the quantity of cal
stance can absorb or give out by
change of temperature, the amount
mined by relation to the quantity whic
of another kind, as water, absorbs or
a like change. Thus the quantity of
to raise oil two degrees will only ra
Hence a pound of water at 212° is s
twice as much heat, or to have twice
for heat, as that of oil.

The specific heat of water being			
"	"	oil	equal
"	"	iron	"
"	"	copper	"
"	"	zinc	"
"	"	mercury	

Gravity.—Gravity or gravitatio
pressure or weight. All bodies po
perty, more or less, proportionate t
degrees of density.

2	48·3	64·4
3	80·5	144·9
4	112·7	257·6
5	144·9	402·5
6	177·1	579·6
7	209·3	788·9
8	241·5	1030·4
9	273·7	1304·1
10	305·9	1610·0

The velocity acquired by a body fall a given height is the same whether it f descena upon a plane any way inclined

Force of gravity is the cause of ret accelerated motion on inclined planes, force being as the height of the plane t On a level line of railway 9½ lbs. tracti come 2240 lbs., or one ton of insistant on an incline or rise of 1 in 350, the traction to overcome the same weig $\frac{2240}{350} = 6·4, + 9·5 = 15·9$ lbs. Again, i be descending, then the force of trac nished in an equal ratio, and the weight by gravity; thus $9·5 - 6·4 = 3·1$ lbs. t traction on the descending plane.

Force of gravity is also the restricti

of each are alike, then stop both and le
freely. Opposite the centre of the
centre of oscillation.

Of Motion.—Motion, in mechanic
is a result or effect of a cause, acting
manner as to impart either linear or circ
by motive power. Thus, the piston
engine by the action of the steam i
produce alternate rectilinear or r
motion. In the fly-wheel, through the
the crank, is produced uniform circul
and by means of eccentric cambs, etc.,
any degree of distortion may easily be

Centrifugal force signifies the ten
bodies acquire, by velocity of circular
fly off in a tangential line from the cen
lution, the amount of tendency being a
of the velocity of the body in motion, he
—Multiply the square of the number o
per minute by the radius of the circl
the weight of the body, and by ·0003
duct is the centrifugal force in terms c
weight. Thus, suppose a body weigh
is describing a circle of 10 feet radius 3

miles, and if the square of the distan
any two points on its surface be div
diameter, the quotient will equal th
altitude between the summit of t
diameter and that of the other point;
distance the excess by level with an
becomes 7·962 inches; at two m
31·848, etc., being as the square of th
hence, the excess subtracted from tl
level, equals the true level as require
sive leveling operations.

Capillary attraction signifies a pro
vable in small tubes, flat, thin spa
substances, as sponge, cotton-wick
threads, etc., of raising water or other
the natural level; hence the applica
principle for obtaining a continued
lubricating fluid between surfaces in
a syphon form of worsted threads,
which is immersed in oil, the other e
serted and supported by the tube thr
the fluid is conducted.

Atmospheric air is a transparent,
subtle, elastic fluid, that naturally su
globe, and in which we breathe for th

Liquids, or ...
incompressible and non-elastic, t
adapted to useful purposes through fl
by agitation and inequality of
hydraulic machines are brought in
useful effects; and although the law
statics and hydraulics are universally
fluids in general, yet water being the
dant in nature it is invariably had re
purposes of motive power.

Fluids when confined exert a fo
every direction, but when unconfined
the same laws as falling bodies in g
fied by mechanical considerations an
tal results, so that through water rol
by the force of gravity, the greate
effect is produced, whether for turbi
wheels.

Liquids, because of their gravity
press equally in every direction; any
ing a liquid sustains a pressure on e
the vessel, equal to as many times
the greatest column or height of
the sectional area of the column i
The amount of pressure sustained

substance required.

Example.—A piece of ye
40 ounces in the air, and being
attached to a piece of iron we
the two together are found to w
water, and the iron alone 25·8 o
required the specific gravity of

$40 + 25·8 = 65·8$, also 65·8
$40 \div 62·5 = ·64$ the specific gravi

The specific gravity of a fl
mined by taking a solid body
sink in the fluid, and of known
weighing it both in the air and
difference between the two we
tiplied by the specific gravity
and the product divided by the
in the air; the quotient will be
of the fluid, that of water bein

Example.—Required the s
given mixture of muriatic acid
of glass, the specific gravity of
3¾ ounces when immersed, and

$6 - 3·75 = 2·25, \times 3 = 6·75, \div$
gravity.

of temperature from 32 to 212

Factors for increase of length.		Factors for i
Glass tube . .	·000861	Gold, to .
Platina . . .	·000884	Copper .
„ . . .	·000992	Silver . .
Iron	·001220	Lead . .
Gold, from . .	·001466	Zinc . .

Hence, the length of a bar of any
named substances will be increased to
its original length at 32°, multiplied b
the table, when raised to a tempera
thus, a bar of iron 50 inches in leng
become expanded at 212°, to ·0012
=50·0061 inches.

Liquefaction, Melting, and Fusic
synonymous terms, but in some insta
different: they each signify a chang
a solid to a liquid state by heat. Ir
of liquefaction, a solvent, as hot wat
thus, neither salt nor sugar can be li
alone. To ice, mercury, tallow, ph
"melting" is the common appellat
being required to liquefy; but to t
fusion is never applied; hence, fus
of metals alone in their

Wrought Iron, to resist torsion at

Velocity by a given Power

Hors's Power.	Number of revolutions per minute of cast									
	20	25	30	35	40	45	50	55	60	65
	Diameters of the shafts in inches.									
10	$5\frac{7}{8}$	$5\frac{3}{4}$	$5\frac{1}{8}$	$4\frac{7}{8}$	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{3}{8}$	$4\frac{1}{4}$	4	4
20	$7\frac{3}{8}$	$6\frac{7}{8}$	$6\frac{3}{8}$	$6\frac{1}{8}$	$5\frac{7}{8}$	$5\frac{5}{8}$	$5\frac{1}{2}$	$5\frac{3}{8}$	$5\frac{1}{8}$	5
30	$8\frac{3}{8}$	$7\frac{7}{8}$	$7\frac{3}{8}$	7	$6\frac{3}{4}$	$6\frac{1}{2}$	$6\frac{1}{4}$	6	$5\frac{7}{8}$	5
40	$9\frac{1}{4}$	$8\frac{5}{8}$	$8\frac{1}{8}$	$7\frac{3}{4}$	$7\frac{1}{4}$	7	$6\frac{7}{8}$	$6\frac{5}{8}$	$6\frac{3}{8}$	6
50	10	$9\frac{1}{4}$	$8\frac{3}{4}$	$8\frac{1}{4}$	8	$7\frac{5}{8}$	$7\frac{3}{8}$	$7\frac{1}{8}$	7	6
60	$10\frac{5}{8}$	$9\frac{7}{8}$	$9\frac{1}{4}$	$8\frac{7}{8}$	$8\frac{3}{4}$	$8\frac{1}{8}$	$7\frac{7}{8}$	$7\frac{5}{8}$	$7\frac{3}{8}$	7
70	$11\frac{1}{4}$	$10\frac{3}{8}$	$9\frac{3}{4}$	$9\frac{1}{4}$	$8\frac{7}{8}$	$8\frac{1}{2}$	$8\frac{1}{4}$	8	$7\frac{3}{4}$	7
80	$11\frac{3}{4}$	$10\frac{7}{8}$	$10\frac{1}{4}$	$9\frac{3}{4}$	$9\frac{1}{4}$	$8\frac{7}{8}$	$8\frac{5}{8}$	$8\frac{3}{8}$	$8\frac{1}{8}$	7
90	$12\frac{1}{8}$	$11\frac{1}{4}$	$10\frac{5}{8}$	$10\frac{1}{8}$	$9\frac{5}{8}$	$9\frac{1}{4}$	9	$8\frac{5}{8}$	$8\frac{3}{8}$	8
100	$12\frac{5}{8}$	$11\frac{3}{4}$	11	$10\frac{1}{2}$	10	$9\frac{5}{8}$	$9\frac{1}{4}$	9	$8\frac{3}{4}$	8
125	$13\frac{1}{2}$	$12\frac{5}{8}$	$11\frac{7}{8}$	$11\frac{1}{4}$	$10\frac{3}{4}$	$10\frac{3}{8}$	10	$9\frac{3}{4}$	$9\frac{3}{8}$	9
150	$14\frac{3}{8}$	$13\frac{3}{8}$	$12\frac{5}{8}$	12	$11\frac{1}{2}$	11	$10\frac{5}{8}$	$10\frac{1}{4}$	10	9
175	$15\frac{1}{8}$	$14\frac{1}{8}$	$13\frac{1}{4}$	$12\frac{5}{8}$	12	$11\frac{1}{2}$	$11\frac{1}{8}$	$10\frac{7}{8}$	$10\frac{1}{2}$	10
200	$15\frac{7}{8}$	$14\frac{3}{4}$	$13\frac{7}{8}$	$13\frac{1}{8}$	$12\frac{5}{8}$	$12\frac{1}{8}$	$11\frac{3}{4}$	$11\frac{3}{8}$	11	10
	Number of revolutions per minute of wrought									
	20	25	30	35	40	45	50	55	60	6
10	5	$4\frac{3}{4}$	$4\frac{3}{8}$	$4\frac{1}{4}$	4	$3\frac{7}{8}$	$3\frac{3}{4}$	$3\frac{5}{8}$	$3\frac{1}{2}$	[illegible]
20	$6\frac{3}{8}$	$5\frac{7}{8}$	$5\frac{1}{2}$	$5\frac{1}{4}$	5	$4\frac{7}{8}$	$4\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{3}{8}$	[illegible]
30	$7\frac{3}{8}$	$6\frac{3}{4}$	$6\frac{3}{8}$	6	$5\frac{3}{4}$	$5\frac{5}{8}$	$5\frac{3}{8}$	$5\frac{1}{4}$	5	[illegible]
40	8	$7\frac{1}{4}$	7	$6\frac{5}{8}$	$6\frac{3}{8}$	$6\frac{1}{8}$	6	$5\frac{3}{4}$	$5\frac{1}{2}$	[illegible]
50	$8\frac{5}{8}$	8	$7\frac{1}{2}$	$7\frac{1}{8}$	$7\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{8}$	$6\frac{1}{8}$	6	[illegible]
60	$9\frac{1}{4}$	$8\frac{1}{2}$	8	$7\frac{5}{8}$	$7\frac{5}{8}$	$6\frac{7}{8}$	$6\frac{3}{4}$	$6\frac{1}{2}$	$6\frac{3}{8}$	[illegible]
70	$9\frac{5}{8}$	9	$8\frac{1}{2}$	8	$7\frac{3}{4}$	$7\frac{3}{8}$	$7\frac{1}{8}$	7	$6\frac{3}{4}$	[illegible]
80	$10\frac{1}{8}$	$9\frac{1}{2}$	$8\frac{7}{8}$	$8\frac{1}{2}$	8	$7\frac{3}{4}$	$7\frac{1}{2}$	$7\frac{1}{4}$	$7\frac{1}{8}$	[illegible]
90	$10\frac{5}{8}$	$9\frac{3}{4}$	$9\frac{1}{4}$	$8\frac{3}{4}$	$8\frac{3}{8}$	8	$7\frac{3}{4}$	$7\frac{1}{2}$	$7\frac{3}{8}$	[illegible]
100	$10\frac{7}{8}$	$10\frac{1}{8}$	$9\frac{5}{8}$	9	$8\frac{5}{8}$	$8\frac{3}{8}$	8	$7\frac{3}{4}$	$7\frac{1}{2}$	[illegible]
125	$11\frac{3}{4}$	$10\frac{7}{8}$	$10\frac{1}{4}$	$9\frac{3}{4}$	$9\frac{1}{4}$	9	$8\frac{5}{8}$	$8\frac{3}{8}$	$8\frac{1}{8}$	[illegible]
150	$12\frac{5}{8}$	$11\frac{1}{2}$	11	$10\frac{3}{8}$	10	$9\frac{5}{8}$	$9\frac{1}{4}$	9	$8\frac{5}{8}$	[illegible]
175	$13\frac{1}{8}$	$12\frac{1}{4}$	$11\frac{1}{2}$	$10\frac{7}{8}$	$10\frac{1}{2}$	10	$9\frac{5}{8}$	$9\frac{3}{8}$	9	[illegible]
200	$13\frac{3}{4}$	$12\frac{3}{4}$	12	$11\frac{3}{8}$	$10\frac{7}{8}$	$10\frac{1}{2}$	$10\frac{1}{8}$	$9\frac{7}{8}$	$9\frac{1}{4}$	[illegible]

eter of bes in ches.	Decimal Numbers.
. . .	·8508
. . .	·9163
. . .	·9817
. . .	1·0471
. . .	1·1778
. . .	1·3088
. . .	1·5708

hole tube surface
ace of a boiler con-
meter, and 6 feet in

13·12 square feet, total

942 square feet, effective

to non-condensing

engine, the diameter
rce of steam being

[redacted]

Diame Cylin in inc	30	35	40	45	5
	Horses power.				
$3\frac{1}{2}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{5}{8}$	1
$3\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{7}{8}$	2
4	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{4}$	2
$4\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{2}$	2
$4\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
$4\frac{3}{4}$	2	$2\frac{3}{8}$	$2\frac{3}{4}$	3	3
5	$2\frac{1}{4}$	$2\frac{5}{8}$	3	$3\frac{3}{8}$	3
$5\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{4}$	$3\frac{3}{4}$	4
$5\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{4}$	$3\frac{1}{2}$	4	4
$5\frac{3}{4}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
6	$3\frac{1}{4}$	$3\frac{3}{4}$	$4\frac{1}{4}$	5	5
$6\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{1}{2}$	5	$5\frac{3}{4}$	6
7	$4\frac{1}{2}$	$5\frac{1}{8}$	$5\frac{3}{4}$	$6\frac{1}{2}$	7
$7\frac{1}{2}$	5	6	$6\frac{3}{4}$	$7\frac{1}{2}$	8
8	$5\frac{3}{4}$	$6\frac{3}{4}$	$7\frac{1}{2}$	$8\frac{1}{2}$	9
$8\frac{1}{2}$	$6\frac{1}{2}$	$7\frac{1}{2}$	$8\frac{1}{2}$	$9\frac{3}{4}$	10
9	$7\frac{1}{4}$	$8\frac{1}{2}$	$9\frac{3}{4}$	11	12
$9\frac{1}{2}$	$8\frac{1}{8}$	$9\frac{1}{2}$	$10\frac{3}{4}$	$12\frac{1}{8}$	13
10	9	$10\frac{1}{2}$	12	$13\frac{1}{2}$	15
11	$10\frac{3}{4}$	$12\frac{5}{8}$	$14\frac{1}{2}$	$16\frac{1}{4}$	18
$11\frac{1}{2}$	12	$13\frac{3}{4}$	$15\frac{3}{4}$	$17\frac{3}{4}$	19
12	13	15	$17\frac{1}{4}$	$19\frac{1}{2}$	21

is not working to any greater degr
than the common slide will effi
Non-condensing engines require n
than a proper supply to the boiler
an addition for leakage, waste, etc
sumption of fuel is as the quan
evaporated, requiring on an aver
11 lbs. of coal per nominal horse p
of the double-cylinder engine c
principles, and only requiring a sim
water for condensation as in the con
and extra fuel as those on the
principle, but to produce the s
power, neither the one nor the o
equal proportions; hence its econ
Thus, an engine with a cylinde
diameter, and steam at 7 lbs. pe
equals 16 horses' power nominally,
a cylinder of 12 inches diameter
40 lbs. per square inch, equals 1
nominally on the non-condensing
an engine on the combined princi
at 40 lbs. per square inch, and c
piston has passed through about ⅓t
in a non-condensing cylinder of 8½

one.

2. When the required pulley is greater
given one.

Rule.—Add double the number B to 2·
from the square root of the sum subtra
and call the remainder E. Multiply the 1
by the distance between the centres, of ·
and the product, added to the radius of
or less pulley, will give the radius of the
or greater pulley.

Ex. 1. Let the distance between the
the shafts equal 36 inches, the radius of
30 inches, and half the length of belt 98·
to find the radius of the other pulley.

3·1416 multiplied by 30	= 94·248
Add distance between shafts	36
	130·248 trial
Subtract half length of belt	98·55
Divide by distance between shafts	36)31·698(·880
From	2 4674
Subtract twice A, or ·8805 × 2 =	1·761
	= ·7064 square r

= ·8404, which subtract from 1 5708 = ·7304, or

Rule.—In each case multiply the circumference in inches by the leng in feet, and use the divisors as follow

For customary measure	2304	For the tru
When $\frac{1}{8}$ the girth is allowed for bark	3009	„
When $\frac{1}{10}$th the girth is allowed for bark	2845	„

Note.—The mean girth is taken for the c

Ex. 1. Required the contents of a t measure, when $\frac{1}{8}$th of the girth is all circumference of mean girth being 4 length of tree 18 feet.

$$48^2 \times 18 = 41472 \div 3009 = 13$$

Ex. 2. Required the true conten dimensions when no allowance for ba

$$41472 \div 1800 = 23 \text{ feet.}$$

On Windmills as as a Motive-powe

Wind, or air in motion become source of motive power through impu the sails of a windmill, and although trustworthy for stability of motion, i for corn and flour mills, pumping of v

The shaft or axle that lies transver

9	81	729	3·0000000
10	100	1000	3·1622777
11	121	1331	3·3166248
12	144	1728	3·4641016
13	169	2197	3·6055513
14	196	2744	3·7416574
15	225	3375	3·8729833
16	256	4096	4·0000000
17	289	4913	4·1231056
18	324	5832	4·2426407
19	361	6859	4·3588989
20	400	8000	4·4721360
21	441	9261	4·5825757
22	484	10648	4·6904158
23	529	12167	4·7958315
24	576	13824	4·8989795
25	625	15625	5·0000000
26	676	17576	5·0990195
27	729	19683	5·1961524
28	784	21952	5·2915026
29	841	24389	5·3851648
30	900	27000	5·4772256
31	961	29791	5·5677644
32	1024	32768	5·6568542
33	1089	35937	5·7445626
34	1156	39304	5·8309519
35	1225	42875	5·9160798
36	1296	46656	6·0000000
37	1369	50653	6·0827625

89	7921	704969	9·4339811	[illegible]
90	8100	729000	9·4868330	[illegible]
91	8281	753571	9·5393920	[illegible]
92	8464	778688	9·5916630	4
93	8649	804357	9·6436508	4
94	8836	830584	9·6953597	4
95	9025	857375	9·7467943	4
96	9216	884736	9·7979590	4
97	9409	912673	9·8488578	4
98	9604	941192	9·8994949	4
99	9801	970299	9·9498744	4
100	10000	1000000	10·0000000	4
101	10201	1030301	10·0498756	4
102	10404	1061208	10·0995049	4
103	10609	1092727	10·1488916	4
104	10816	1124864	10 1980390	4
105	11025	1157625	10·2469508	4
106	11236	1191016	10·2956301	4
107	11449	1225043	10·3440804	4
108	11664	1259712	10·3923048	4
109	11881	1295029	10·4403065	4
110	12100	1331000	10·4880885	4
111	12321	1367631	10·5356538	4
112	12544	1404928	10·5830052	4
113	12769	1442897	10·6301458	4
114	12996	1481544	10·6770783	4
115	13225	1520875	10 7238053	4
116	13456	1560896	10·7703296	4
117	13689	1601613	10·8166538	4
118	13924	1643032	10 8627805	4

168	28224	4741632	12·9614814
169	28561	4826809	13·0000000
170	28900	4913000	13·0384048
171	29241	5000211	13·0766968
172	29584	5088448	13·1148770
173	29929	5177717	13·1529464
174	30276	5268024	13·1909060
175	30625	5359375	13·2287566
176	30976	5451776	13·2664992
177	31329	5545233	13·3041347
178	31684	5639752	13·3416641
179	32041	5735339	13·3790882
180	32400	5832000	13·4164079
181	32761	5929741	13·4536240
182	33124	6028568	13·4907376
183	33489	6128487	13·5277493
184	33856	6229504	13·5646600
185	34225	6331625	13·6014705
186	34596	6434856	13·6381817
187	34969	6539203	13·6747943
188	35344	6644672	13·7113092
189	35721	6751269	13·7477271
190	36100	6859000	13·7840488
191	36481	6967871	13·8202750
192	36864	7077888	13·8564065
193	37249	7189057	13·8924440
194	37636	7301384	13·9283883
195	38025	7414875	13·9642400
196	38416	7529536	14·0000000
197	38809	7645373	14·0356688

249	62001	15438249	15·7797338
250	62500	15625000	15·8113883
251	63001	15813251	15·8429795
252	63504	16003008	15·8745079
253	64009	16194277	15·9059737
254	64516	16387064	15·9373775
255	65025	16581375	15·9687194
256	65536	16777216	16·0000000
257	66049	16974593	16·0312195
258	66564	17173512	16·0623784
259	67081	17373979	16·0934769
260	67600	17576000	16·1245155
261	68121	17779581	16·1554944
262	68644	17984728	16·1864141
263	69169	18191447	16·2172747
264	69696	18399744	16·2480768
265	70225	18609625	16·2788206
266	70756	18821096	16·3095064
267	71289	19034163	16·3401346
268	71824	19248832	16·3707055
269	72361	19465109	16·4012195
270	72900	19683000	16·4316767
271	73441	19902511	16·4620776
272	73984	20123648	16·4924225
273	74529	20346417	16·5227116
274	75076	20570824	16·5529454
275	75625	20796875	16·5831240
276	76176	21024576	16·6132477
277	76729	21253933	16·6433170

Cube Root.
6·847021
6·854124
6·861212
6·868285
6·875344
6·882389
6·889419
6·896435
6·903436
6·910423
6·917396
6·924356
6·931301
6·938232
6·945150
6·952053
6 958943
6·965820
6·972683
6·979532
6·986368
6·993191
7·000000
7·006796
7 013579
7·020349
7·027106
7·033850

[redacted]

409	167281	68417929	20·2237484
410	168100	68921000	20·2484567
411	168921	69426531	20·2731349
412	169744	69934528	20·2977831
413	170569	70444997	20·3224014
414	171396	70957944	20·3469899
415	172225	71473375	20·3715488
416	173056	71991296	20·3960781
417	173889	72511713	20·4205779
418	174724	73034632	20·4450483
419	175561	73560059	20·4694895
420	176400	74088000	20·4939015
421	177241	74618461	20·5182845
422	178084	75151448	20·5426386
423	178929	75686967	20·5669638
424	179776	76225024	20·5912603
425	180625	76765625	20·6155281
426	181476	77308776	20·6397674
427	182329	77854483	20·6639783
428	183184	78402752	20·6881609
429	184041	78953589	20·7123152
430	184900	79507000	20·7364414
431	185761	80062991	20·7605395
432	186624	80621568	20·7846097
433	187489	81182737	20·8086520
434	188356	81746504	20·8326667
435	189225	82312875	20·8566536
436	190096	82881856	20·8806130
437	190969	83453453	20·9045450

489	239121	116930169	22·1133444
490	240100	117649000	22·1359436
491	241081	118370771	22·1585198
492	242064	119095488	22·1810730
493	243049	119823157	22·2036033
494	244036	120553784	22·2261108
495	245025	121287375	22·2485955
496	246016	122023936	22 2710575
497	247009	122763473	22·2934968
498	248004	123505992	22·3159136
499	249001	124251499	22·3383079
500	250000	125000000	22·3606798
501	251001	125751501	22·3830293
502	252004	126506008	22·4053565
503	253009	127263527	22·4276615
504	254016	128024064	22·4499443
505	255025	128787625	22·4722051
506	256036	129554216	22·4944438
507	257049	130323843	22·5166605
508	258064	131096512	22·5388553
509	259081	131872229	22·5610283
510	260100	132651000	22·5831796
511	261121	133432831	22·6053091
512	262144	134217728	22·6274170
513	263169	135005697	22·6495033
514	264196	135796744	22·6715681
515	265225	136590875	22·6936114
516	266256	137388096	22·7156334
517	267289	138188413	22·7376340

568	322624	183250432	23·83
569	323761	184220009	23·85
570	324900	185193000	23·87
571	326041	186169411	23·89
572	327184	187149248	23·91
573	328329	188132517	23·93
574	329476	189119224	23·95
575	330625	190109375	23·97
576	331776	191102976	24·00
577	332929	192100033	24·02
578	334084	193100552	24·04
579	335241	194104539	24·06
580	336400	195112000	24·08
581	337561	196122941	24·10
582	338724	197137368	24·124
583	339889	198155287	24·145
584	341056	199176704	24·16
585	342225	200201625	24·18
586	343396	201230056	24·207
587	344569	202262003	24·228
588	345744	203297472	24·248
589	346921	204336469	24·269
590	348100	205379000	24·289
591	349281	206425071	24·310
592	350464	207474688	24·331
593	351649	208527857	24·351
594	352836	209584584	24·372
595	354025	210644875	24·392
596	355216	211708736	24·413
597	356409	212776173	24·433

648	419904	272097792	25·455
649	421201	273359449	25·475
650	422500	274625000	25·495
651	423801	275894451	25·514
652	425104	277167808	25·534
653	426409	278445077	25·553
654	427716	279726264	25·573
655	429025	281011375	25·592
656	430336	282300416	25·612
657	431649	283593393	25·632
658	432964	284890312	25·651
659	434281	286191179	25·670
660	435600	287496000	25·690
661	436921	288804781	25·709
662	438244	290117528	25·729
663	439569	291434247	25·7487
664	440896	292754944	25·7681
665	442225	294079625	25·7875
666	443556	295408296	25·806
667	444889	296740963	25 8263
668	446224	298077632	25·8456
669	447561	299418309	25·8650
670	448900	300763000	25·8843
671	450241	302111711	25·9036
672	451584	303464448	25·9229
673	452929	304821217	25·9422
674	454276	306182024	25·9615
675	455625	307546875	25·9807
676	456976	308915776	26·0000
677	458329	310288733	26·0192

728	529984	385828352	26·981
729	531441	387420489	27·000
730	532900	389017000	27·018
731	534361	390617891	27·037
732	535824	392223168	27·055
733	537289	393832837	27·073
734	538756	395446904	27·092
735	540225	397065375	27·110
736	541696	398688256	27·129
737	543169	400315553	27·147
738	544644	401947272	27·166
739	546121	403583419	27·184
740	547600	405224000	27·202
741	549081	406869021	27·221
742	550564	408518488	27·239
743	552049	410172407	27·258
744	553536	411830784	27·276
745	555025	413493625	27·294
746	556516	415160936	27·313
747	558009	416832723	27·331
748	559504	418508992	27·349
749	561001	420189749	27·367
750	562500	421875000	27·386
751	564001	423564751	27·404
752	565504	425259008	27·422
753	567009	426957777	27·440
754	568516	428661064	27·459
755	570025	430368875	27·477
756	571536	432081216	27·495

808	652864	527514112	28·42
809	654481	529475129	28·44
810	656100	531441000	28·46
811	657721	533411731	28·47
812	659344	535387328	28·49
813	660969	537367797	28·51
814	662596	539353144	28·53
815	664225	541343375	28·54
816	665856	543338496	28·56
817	667489	545338513	28·58
818	669124	547343432	28·60
819	670761	549353259	28·61
820	672400	551368000	28·63
821	674041	553387661	28·653
822	675684	555412248	28·670
823	677329	557441767	28·687
824	678976	559476224	28·705
825	680625	561515625	28·722
826	682276	563559976	28·740
827	683929	565609283	28·757
828	685584	567663552	28·774
829	687241	569722789	28·792
830	688900	571787000	28·809
831	690561	573856191	28·827
832	692224	575930368	28·844
833	693889	578009537	28·861
834	695556	580093704	28·879
835	697225	582182875	28·896
836	698896	584277056	28·913
837	700569	[illegible]	[illegible]

888	788544	70022
889	790321	70259
890	792100	70496
891	793881	70734
892	795664	70973
893	797449	71212
894	799236	71451
895	801025	71691
896	802816	71932
897	804609	721734
898	806404	724150
899	808201	726572
900	810000	729000
901	811801	731432
902	813604	733870
903	815409	736314
904	817216	738763
905	819025	741217
906	820836	7436774
907	822649	7461426
908	824464	7486133
909	826281	7510894
910	828100	7535710
911	829921	7560580
912	831744	7585505
913	833569	7610484
914	835396	7635519
915	837225	7660608
916	839056	7685752
917	840889	[illegible]

No.	Square.	Cube.	Sq. Root.	Cube Root.
921	848241	781229961	30·3479818	9·729411
922	850084	783777448	30·3644529	9·732931
923	851929	786330467	30·3809151	9·736448
924	853776	788889024	30·3973683	9·739963
925	855625	791453125	30·4138127	9·743476
926	857476	794022776	30·4302481	9·746986
927	859329	796597983	30·4466747	9·750493
928	861184	799178752	30·4630924	9·753998
929	863041	801765089	30·4795013	9·757500
930	864900	804357000	30·4959014	9·761000
931	866761	806954491	30·5122926	9·764497
932	868624	809557568	30·5286750	9·767992
933	870489	812166237	30·5450487	9·771484
934	872356	814780504	30·5614136	9·774974
935	874225	817400375	30·5777697	9·778462
936	876096	820025856	30·5941171	9·781947
937	877969	822656953	30·6104557	9·785429
938	879844	825293672	30·6267857	9·788909
939	881721	827936019	30·6431069	9·792386
940	883600	830584000	30·6594194	9·795861
941	885481	833237621	30·6757233	9·799334
942	887364	835896888	30·6920185	9·802804
943	889249	838561807	30·7083051	9·806271
944	891136	841232384	30·7245830	9·809736
945	893025	843908625	30·7408523	9·813199
946	894916	846590536	30·7571130	9·816659
947	896809	849278123	30·7733651	9·820117
948	898704	851971392	30·7896086	9·823572
949	900601	854670349	30·8058436	9·827025
950	902500	857375000	30·8220700	9·830476
951	904401	860085351	30·8382879	9·833924
952	906304	862801408	30·8544972	9·837369
953	908209	865523177	30·8706981	9·840813
954	910116	868250664	30·8868904	9·844254
955	912025	870983875	30·9030743	9·847692
956	913936	873722816	30·9192497	9·851128
957	915849	876467493	30·9354166	9·854562
958	917764	879217912	30·9515751	9·857993
959	919681	881974079	30·9677251	9·861422
960	921600	884736000	30·9838668	9·864848

968	937024	90703
969	938961	909853
970	940900	912673
971	942841	915498
972	944784	918330
973	946729	921167
974	948676	924010
975	950625	926859
976	952576	929714
977	954529	932574
978	956484	935441
979	958441	938313
980	960400	941192
981	962361	944076
982	964324	946966
983	966289	949862
984	968256	952763
985	970225	955671
986	972196	958585
987	974169	961504
988	976144	964430
989	978121	967361
990	980100	970299
991	982081	973242
992	984064	976191
993	986049	979146
994	988036	982107
995	990025	985074
996	992016	988047
997	994009	991026

Table of Squares, Cubes, and Fourth Power of Numbers.

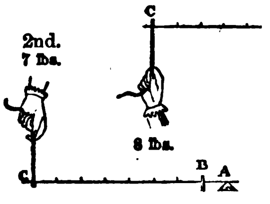
Root.	Square.	Cube.	4th Power.	Root.	Square.	Cube.	4th Power.
1	1	1	1	7	49	343	2401
·1	1·21	1·331	1·4641	·1	50·41	357·911	2541·1681
·2	1·44	1·728	2·0736	·2	51·84	373·248	2687·3856
·3	1·69	2·197	2·8561	·3	53·29	389·017	2839·8241
·4	1·96	2·744	3·8416	·4	54·76	405·224	2998·6576
·5	2·25	3·375	5·0625	·5	56·25	421·875	3163·8625
·6	2·56	4·096	6·5536	·6	57·76	438·976	3346·2176
·7	2·89	4·913	8·3521	·7	59·29	456·533	3515·3041
·8	3·24	5·832	10·5876	·8	60·84	474·552	3701·4756
·9	3·61	6·859	13·0321	·9	62·41	493·039	3895·0081
2	4	8	16	8	64	512	4096
·1	4·41	9·261	19·4481	·1	65·61	531·441	4304·6721
·2	4·84	10·648	23·4256	·2	67·24	551·368	4521·2176
·3	5·29	12·167	27·8841	·3	68·89	571·787	4745·8221
·4	5·76	13·824	33·1776	·4	70·56	592·704	4979·5836
·5	6·25	15·625	39·0625	·5	72·25	614·125	5220·0625
·6	6·76	17·576	45·6976	·6	73·96	636·056	5470·0816
·7	7·29	19·683	53·1441	·7	75·69	658·503	5728·9761
·8	7·84	21·952	61·4656	·8	77·44	681·472	5996·9536
·9	8·41	24·389	70·7281	·9	79·21	704·969	6274·2141
3	9	27	81	9	81	729	6561
·1	9·61	29·791	92·3521	·1	82·81	753·571	6857·4961
·2	10·24	32·768	104·8576	·2	84·64	778·688	7173·9296
·3	10·89	35·937	118·5921	·3	86·49	804·357	7479·5201
·4	11·56	39·304	133·6336	·4	88·36	830·584	7807·4896
·5	12·25	42·875	150·0625	·5	90·25	857·375	8075·0525
·6	12·96	46·656	167·9616	·6	92·16	884·736	8493·6656
·7	13·69	50·653	187·4161	·7	94·09	912·673	8751·9281
·8	14·44	54·872	208·5136	·8	96·04	941·192	9231·6816
·9	15·21	59·319	231·3441	·9	98·01	970·299	9308·9601
4	16	64	256	10	100	1000	10000
·1	16·81	68·921	282·5761	·1	102·01	1030·301	10406·0401
·2	17·64	74·088	311·1696	·2	104·04	1061·208	10624·3216
·3	18·49	79·507	341·8801	·3	106·09	1092·727	11255·0881
·4	19·36	85·184	374·8096	·4	108·16	1124·864	11698·5856
·5	20·25	91·125	410·0625	·5	110·25	1157·625	12155·0625
·6	21·16	97·336	447·7456	·6	112·36	1191·016	12624·7696
·7	22·09	103·823	487·9681	·7	114·49	1225·043	13107·9601
·8	23·04	110·592	530·8416	·8	116·64	1259·712	13604·8896
·9	24·01	117·649	576·4801	·9	118·81	1295·029	14115·8161
5	25	125	625	11	121	1331	14641
·1	26·01	132·651	676·5201	·1	123·21	1367·631	15180·7041
·2	27·04	140·608	731·1616	·2	125·44	1404·928	15735·1936
·3	28·09	148·877	789·0481	·3	127·69	1442·897	16314·7361
·4	29·16	157·464	850·3056	·4	129·96	1481·544	16899·6016
·5	30·25	166·375	915·0625	·5	132·25	1520·875	17490·0625
·6	31·36	175·616	983·4496	·6	134·56	1560·896	18106·3936
·7	32·49	185·193	1055·6001	·7	136·89	1601·613	18749·9721
·8	33·64	195·112	1131·6496	·8	139·24	1643·032	19387·7776
·9	34·81	205·379	1211·7361	·9	141·61	1685·159	20153·3921
6	36	216	1296	12	144	1728	20736
·1	37·21	226·981	1384·5841	·1	146·41	1771·561	21345·8881
·2	38·44	238·328	1477·6336	·2	148·84	1815·848	22253·4556
·3	39·69	250·047	1575·2961	·3	151·29	1860·867	22898·6641
·4	40·96	262·144	1677·7216	·4	153·76	1906·624	23642·1376
·5	42·25	274·625	1785·0625	·5	156·25	1953·125	24414·0625
·6	43·56	287·496	1897·4736	·6	158·76	2000·376	25204·7376
·7	44·89	300·763	2015·1121	·7	161·29	2048·383	26011·6641
·8	46·24	314·432	2138·1376	·8	163·84	2097·152	26843·545
·9	47·61	328·509	2266·7121	·9	166·41	2146·689	27692·388

They are usually account
lever, the *wh^el* and *axle*,
plane, the *wedge*, and the
of these comprise the who
inclined plane,—the wheel a
of the first kind, and the pu
—the wedge and the screw
to that of the inclined plane
seems to be the case in thes
require, on account of thei
peculiar rule of estimation
different circumstances in wl
required to act.

1. THE I

Levers, according to mo
following,

1st.



are distinguished as being of the first, second, or third kind; and although levers of equal lengths produce different effects, the general principles of estimation in all are the same; namely, the power is to the weight or resistance, as the distance of the one end of the fulcrum is to the distance of the other end to the same point.

In the *first kind*, the power is to the resistance, as the distance A B is to the distance B C.

In the *second*, the power is to the resistance, as the distance A B is to that of A C; and,

In the *third*, the resistance is to the power, as the distance A B is to that of A C.

Rule, first kind.—Divide the longer by the shorter end of the lever from the fulcrum, and the quotient is the effective force that the power supplied is equal to.

Ex. 1. Let the handle of a pump equal 65 inches in length, and 10 inches from the shortest end to centre of motion; what is the amount of effective leverage thereby obtained?

$$65-10=55, \text{ and } \frac{55}{10}=5\tfrac{1}{2} \text{ to } 1.$$

Ex. 2. Required the situation of the fulcrum on which to rest a lever of 15 feet, so that $2\frac{1}{2}$ cwt. placed at one end may equipoise 30 cwt. at the other, the weight of the lever not being taken into account.

$\frac{15 \times 2{\cdot}5}{2{\cdot}5+30}=1{\cdot}154$ feet from the end on which the 30 cwt. is to be placed.

The common steelyard, or Roman balance, as represented in fig. 1, Plate D, is a lever of the first kind, and so divided that one weight W, moved to or from the axis of motion, will equipoise and there indicate the weight of any article required to be known.

proportion of effect that the pow
or resistance to be overcome.

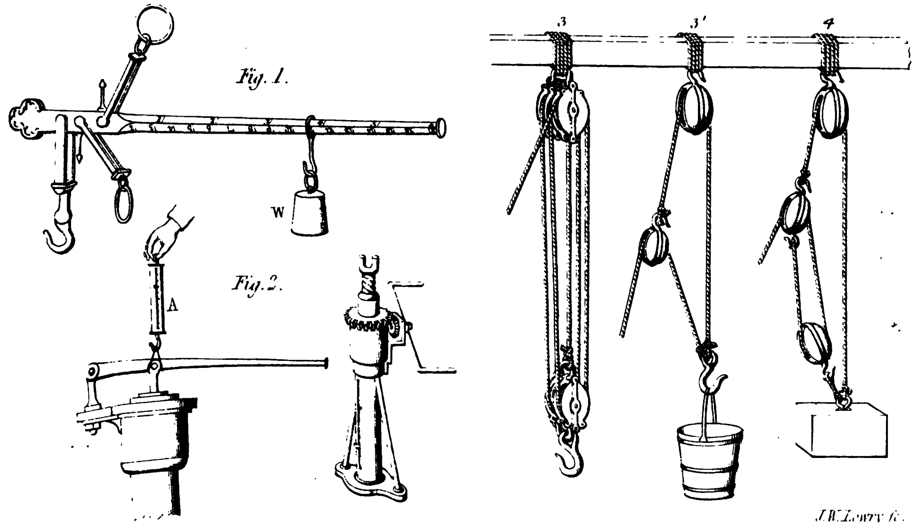
Ex. Required the amount of e
duced by a power of 50lbs. on the
pump, the length of the lever bei
tance from ram to fulcrum $4\frac{1}{2}$ incl

3 feet=36 inches, and $\frac{36}{4 \cdot 5}=8$, or the
are to each other as 8 to 1; hence
upon the ram.

The lever on the safety-valve of
the *third kind*, the action of the ste
and the weight or spring-balance
ance; but in such application the
weight must also be taken into a
simply ascertained by such mean
fig 2, plate D, where A is a *Salte*
to the lever by a light line, imme
of pressure on the valve, and wh
or otherwise, will indicate the le
point.

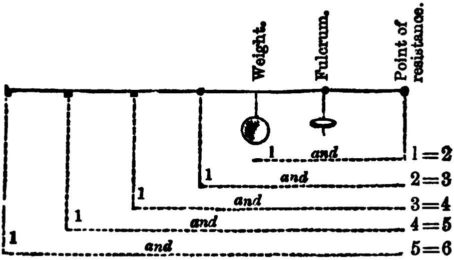
This is perhaps the most fre
the third kind of lever to mecha
that in which great nicety is req

APPLICATIONS OF MECHANIC POWERS.



London: Lockwood & Co. Stationers' Hall Court

sistance, as shown in the annexed diagram to illustrate this particular case.



Thus, suppose the weight to be placed on any one of the divisions, it is still the same weight, or 1; but because of the principle of the lever, the resistance is increased equal to the number of times the weight is distant from the fulcrum; consequently the action of the lever tends to press down the valve equal the sum of the weight and resistance, or the number of times the weight is distant from the resistance.

2. THE WHEEL AND PINION, OR CRANE.

The mechanical advantage of the wheel and axle, or crane, is as the velocity of the weight to the velocity of the power; and being only a modification of the first kind of lever, it of course partakes of the same principles.

1. *To determine the amount of effective power produced from a given power by means of a crane with known peculiarities.*

Rule.—Multiply together the diameter of the circle described by the winch, or handle, and the number of revolutions of the pinion to 1 of the wheel; divide the product by the barrel's diameter in equal terms

g ...... into accou

$\frac{30 \times 8}{11}$=21·8 to 1 of exertive force; an

2. *Given any two parts of a cra that shall produce any required chanical effect.*

Rule.—Multiply the two given divide the product by the required p the quotient is the dimensions of equal terms of unity.

Ex. Suppose that a crane is requ power to effect being as 40 to 1, and pinion 11 to 1 is unavoidably employed, also the throw of each inches; what must be the barrel's di the rope or chain must coil?

16 × 2=32 inches diameter of circle d

And $\frac{32 \times 11}{40}$=8·8 inches, the barrel's

3. THE PULLEY.

The principle of the pulley, or the block and tackle, is the distribut various points of support; the mech derived depending entirely upon th tension of th

the power is to the weight as the number of cords attached to the lower block; whence the following rules.

1. Divide the weight to be raised by the number of cords leading *to*, *from*, or *attached* to the lower block; and the quotient is the power required to produce an equilibrium, provided friction did not exist.

2. Divide the weight to be raised by the power to be applied; the quotient is the number of sheives in, or cords attached to the rising block.

Ex. Required the power necessary to raise a weight of 3000 lbs. by a four and five-sheived block and tackle, the four being the moveable or rising block.

Necessarily there are nine cords leading to and from the rising block.

Consequently $\frac{3000}{9}=333$ lbs., the power required.

Ex. 2. I require to raise a weight of 1 ton 18 cwt., or 4256 lbs.; the amount of my power to effect this object being 500 lbs., what kind of block and tackle must I of necessity employ?

$\frac{4256}{500}=8{\cdot}51$ cords; of necessity there must be 4 sheives or 9 cords in the rising block.

As the effective power of the crane may, by additional wheels and pinions, be increased to any required extent, so may the pulley and tackle be similarly augmented by purchase upon purchase; two of the most useful of such applications being represented in figs. 3 and 4, Plate D, the first of which is known by the term *runner and tackle*, and the second by that of *Spanish burton*.

the rise to so many parts in a certa
tance, as 1 in 100, 1 in 200, &c., t
representing the perpendicular heigh
the horizontal length in attaining su
numbers being of the same denominati
wise expressed; but it may be neces
that the inclination of a plane, the sir
the height per mile, or the height for
ratio, &c., are all synonymous terms.

The advantage gained by the inclir
the power acts in a parallel direction
as the length to the height. H
Divide the weight by the ratio of i
the quotient equal the power that wi
that weight upon the plane. Or,
weight by the height of the plane, an
length,—the quotient is the power.

Ex. Required the power or equ
capable of supporting a load of 350 lb
of 1 in 12, or 3 feet in height and 36

$$\frac{350}{12} = 29{\cdot}16 \text{ lbs., or } \frac{350 \times 3}{36} = 29{\cdot}16 \text{ lbs. pov}$$

Note.—The weight multiplied by the lengt
the product divided by the length of the inc
equal the pressure or ...

Table showing the Resistance opposed to the Motion of Carriages on different Inclinations of Ascending or Descending Planes, whatever part of the insistent weight they are drawn by.

Tens.	Hundreds.									
		100	200	300	400	500	600	700	800	900
		·01	·005	·00333	·0025	·002	·00167	·00143	·00125	·00111
10	·1	·00909	·00476	·00322	·00244	·00196	·00164	·00141	·00123	·0011
20	·05	·00833	·00454	·00312	·00238	·00192	·00161	·00139	·00122	·00109
30	·0333	·00769	·00435	·00303	·00232	·00189	·00159	·00137	·0012	·00107
40	·025	·00714	·00417	·00294	·00227	·00185	·00156	·00135	·00119	·00106
50	·02	·00667	·004	·00286	·00222	·00182	·00154	·00133	·00118	·00105
60	·0166	·00625	·00385	·00278	·00217	·00178	·00151	·00131	·00116	·00104
70	·0143	·00588	·0037	·0027	·00213	·00175	·00149	·0013	·00115	·00103
80	·0125	·00555	·00357	·00263	·00208	·00172	·00147	·00128	·00114	·00102
90	·0111	·00526	·00345	·00256	·00204	·00169	·00145	·00126	·00112	·00101

***Note.*—Although this Table has been calculated particula for carriages on railway inclines, it may with equal propriety applied to any other incline, the amount of traction on a l being known.**

Added tog

Then $\frac{150}{\cdot 00711}$=21097 lbs. weight drawn up th

2. What weight would a force of 15 down the same plane, the friction on the the same as before?

Friction on the level=·00417
Gravity of the plane=·00294 subtract

$$=\cdot 00123$$

And $\frac{150}{\cdot 00123}$=121915 lbs. weight drawn down

Example of incline when velocity is taken i

A power of 230 lbs., at a velocity of minute, is to be employed for moving an inclined plane 12 feet in height and length, the least velocity of the weight to per minute; required the greatest weigh power is equal to.

$$\frac{230 \times 75 \times 163}{12 \times 8} = \frac{2811750}{96} = 29288 \text{ lbs., or } 13\cdot$$

TABLE OF INCLINED PLANES,

Showing the ascent or descent per yard, and the corresponding ascent or descent per chain, per mile; and also the ratio.

Per yard.		Per chain.	Per mile.	Ratio.	Per yard.		Per chain.	Per mile.	Ratio.
In parts of an in.	In decls. of an inch.	Inches.	Feet.	One in	In parts of an in.	In decls. of an inch.	Inches.	Feet.	One in
$\frac{1}{64}$	·0156	·344	2·29	2304	$\frac{7}{16}$	·4375	9·625	64·17	82
$\frac{1}{48}$	·0208	·458	3·06	1728	$\frac{1}{2}$	·5	11	73·33	72
$\frac{1}{32}$	·0312	·687	4·58	1152	$\frac{9}{16}$	·5625	12·375	82·5	64
$\frac{1}{24}$	·0417	·917	6·11	864	$\frac{7}{12}$	·5833	12·833	85·56	62
$\frac{1}{16}$	·0625	1·375	9·17	576	$\frac{3}{5}$	·6	13·2	88	60
$\frac{1}{12}$	·0833	1·833	12·22	432	$\frac{5}{8}$	·625	13·75	91·67	58
$\frac{1}{10}$	·1	2·2	14·67	360	$\frac{2}{3}$	·6667	14·667	97·78	54
$\frac{1}{8}$	·125	2·75	18·33	288	$\frac{11}{16}$	·6875	15·125	100·83	52
$\frac{1}{6}$	·1667	3·667	24·44	216	$\frac{7}{10}$	·7	15·4	102·67	51
$\frac{3}{16}$	·1875	4·125	27·50	192	$\frac{3}{4}$	·75	16·5	110	48
$\frac{1}{5}$	·2	4·4	29·33	180	$\frac{4}{5}$	·8	17·6	117·33	45
$\frac{1}{4}$	·25	5·5	36·67	144	$\frac{13}{16}$	·8125	17·875	119·17	44
$\frac{3}{10}$	·3	6·6	44	120	$\frac{5}{6}$	·8333	18·333	122·22	43
$\frac{5}{16}$	·3125	6·875	45·83	115	$\frac{7}{8}$	·875	19·25	128·33	41
$\frac{1}{3}$	·3333	7·333	48·89	108	$\frac{9}{10}$	·9	19·8	132	40
$\frac{3}{8}$	·375	8·25	55	96	$\frac{11}{12}$	·9167	20·167	134·44	39
$\frac{2}{5}$	·4	8·8	58·67	20	$\frac{15}{16}$	·9375	20·625	137·5	38
$\frac{5}{12}$	·4167	9·167	61·11	86	1	1	22	146·67	36

inclined sides; the quotient is the fo
resistance.

Ex. The breadth of the back or l
being 3 inches, and its inclined sides
required the power necessary to act
so as to separate two substances whos
is equal to 150 lbs.

$$\frac{150 \times 1{\cdot}5}{10} = 22{\cdot}5 \text{ lbs.}$$

Note.—When only one of the bodies is mo
breadth of the wedge is taken for the mult

THE SCREW.

The screw, in principle, is that of an
wound around a cylinder which gener
uniform inclination, each revolution p
or traverse motion equal to the pitch o
distance between two consecutive threa
being the height or angle of inclinatio
cumference the length of the plane w
not applied; but the lever being a nec
cation of the screw, the circle which
taken, instead of the screw's circumf

the lever where the power acts, is to the pitch of the screw, so is the force to the resistance.

Ex. 1. Required the effective power obtained by a screw of $\frac{7}{8}$ inch pitch, and moved by a force equal to 50 lbs. at the extremity of a lever 30 inches in length.

$$\frac{30 \times 2 \times 3{\cdot}1416 \times 50}{{\cdot}875} = 10760 \text{ lbs.}$$

Ex. 2. Required the power necessary to overcome a resistance equal to 7000 lbs. by a screw of $1\frac{1}{4}$ inch pitch, and moved by a lever 25 inches in length.

$$\frac{7000 \times 1{\cdot}25}{25 \times 2 \times 3{\cdot}1416} = 55{\cdot}73 \text{ lbs. power.}$$

In the case of a screw acting on the periphery of a toothed wheel, the power is to the resistance as the product of the circle's circumference described by the winch or lever, and radius of the wheel, to the product of the screw's pitch, and radius of the axle, or point whence the power is transmitted; but observe, that if the screw consist of more than one helix or thread, the apparent pitch must be increased so many times as there are threads in the screw. *Hence, to find what weight a given power will equipoise:*

Rule.—Multiply together the radius of the wheel, the length of the lever at which the power acts, the magnitude of the power, and the constant number 6·2832; divide the product by the radius of the axle into the pitch of the screw, and the quotient is the weight that the power is equal to.

Ex. What weight will be sustained in equilibrio by a power of 100 lbs. acting at the end of a lever 24 inches in length, the radius of the axle, or point whence the power is transmitted, being 8 inches, the

power and weight.

OF CONTINUOUS CIRCULAR

In mechanics, circular motion is transm
of *wheels*, *drums*, or *pulleys*; and acco
driving and driven are of equal or uneq
so are equal or unequal velocities produc
principle on which the following rules a

1. WHEN TIME IS NOT TAKEN INT

Rule.—Divide the greater diameter,
teeth, by the lesser diameter, or numbe
the quotient is the number of revoluti
will make for 1 of the greater.

Ex. How many revolutions will a pini
make for 1 of a wheel with 125?

$125 \div 20 = 6{\cdot}25$, or $6\frac{1}{4}$ revolution

Note.—Intermediate wheels of whatever dia

To find the number of revolutions of the last, to 1 *of the first, in a train of wheels and pinions.*

Rule.—Divide the product of all the teeth in the driving by the product of all the teeth in the driven, and the quotient equal the ratio of velocity required.

Ex. 1. Required the ratio of velocity of the last, to 1 of the first, in the following train of wheels and pinions; viz., *pinions driving,*—the first of which contains 10 teeth, the second 15, and third 18;—*wheels driven,*—first 15 teeth, second 25, and third 32.

$$\frac{10\times15\times18}{15\times25\times32}=\cdot225$$ of a revolution the wheel will make to 1 of the pinion.

Ex. 2. A wheel of 42 teeth giving motion to one of 12, on which shaft is a pulley of 21 inches diameter, driving one of 6; required the number of revolutions of the last pulley to one of the first wheel.

$$\frac{42\times21}{12\times6}=12\cdot25, \text{ or } 12\tfrac{1}{4} \text{ revolutions.}$$

Note.—Where increase or decrease of velocity is required to be communicated by wheel-work, it has been demonstrated that the number of teeth on each pinion should not be less than 1 to 6 of its wheel, unless there be some other important reason for a higher ratio.

2. WHEN TIME MUST BE REGARDED.

Rule.—Multiply the diameter, or number of teeth in the driver, by its velocity in any given time, and divide the product by the required velocity of the driven; the quotient equal the number of teeth, or diameter of the driven, to produce the velocity required.

Ex. 1. If a wheel containing 84 teeth makes 20 revolutions per minute, how many must another contain to work in contact, and make 60 revolutions in the same time?

$$\frac{84\times20}{60}=28 \text{ teeth.}$$

Ex. 3. Required the diameter
16 revolutions in the same time a
making 36.

$$\frac{24 \times 36}{16} = 54 \text{ inches}$$

*The distance between the centre
two wheels being given, to find their*

Rule.—Divide the greatest vel
the quotient is the ratio of diamete
bear to each other. Hence, divide
tween the centres by the ratio plu
equal the radius of the smaller wh
the radius thus obtained from the
the centres; the remainder equal t
other.

Ex. The distance of two shafts
centre is 50 inches, and the velocit
revolutions per minute, the other is t
same time; the proper diameters of
pitch lines are required.

$80 \div 25 = 3{\cdot}2$, ratio of velocity, and $\frac{50}{3{\cdot}2+}$

of the smaller wheel; then $50 - 11{\cdot}9 = 38$
their diameters are $11{\cdot}9 \times 2 = 23{\cdot}8$, and 38

attained:—Multiply the given and required velocities together, and the square root of the product is the mean or proportionate velocity.

Ex. Let the given velocity of a wheel containing 54 teeth equal 16 revolutions per minute, and the given diameter of an intermediate pulley equal 25 inches, to obtain a velocity of 81 revolutions in a machine; required the number of teeth in the intermediate wheel, and diameter of the last pulley.

$\sqrt{81 \times 16} = 36$ mean velocity.

$\frac{54 \times 16}{36} = 24$ teeth, and $\frac{25 \times 36}{81} = 11{\cdot}1$ inches, diameter of pulley.

To determine the proportion of wheels for screw-cutting by a Lathe.

In a lathe properly adapted, screws to any degree of pitch, or number of threads in a given length, may be cut by means of a leading screw of any given pitch, accompanied with change wheels and pinions; course pitches being effected generally by means of one wheel and one pinion with a *carrier*, or *intermediate wheel*, which cause no variation or change of motion to take place: hence the following

Rule.—Divide the number of threads in a given length of the screw which is to be cut, by the number of threads in the same length of the leading screw attached to the lathe; and the quotient is the ratio that the wheel on the end of the screw must bear to that on the end of the lathe spindle.

Ex. Let it be required to cut a screw with 5 threads in an inch, the leading screw being of $\frac{1}{2}$ inch pitch, or containing two threads in an inch; what must be the ratio of wheels applied?

$5 \div 2 = 2{\cdot}5$, the ratio they must bear to each other.

stud, are commonly designated t
stud-wheel and *pinion* ; but the n
and ratio of screw are the same a
rule ;—hence, all that is further
upon any 3 wheels at pleasure,
spindle and stud-wheels,—then m
of teeth in the spindle-wheel by th
and by the number of teeth in tl
which is in contact with the wheel
screw; divide the product by the
tact with the spindle-wheel, and tl
number of teeth required in the w
the leading screw.

Ex. Suppose a screw is requir
taining 25 threads in an inch, th
before having 2 threads in an
wheel of 60 teeth is fixed upon fo
spindle, 20 for the pinion in conta
wheel, and 100 for that in contact
the end of the spindle;—required tl
in the wheel for the end of the lead

$$25 \div 2 = 12{\cdot}5, \text{ and } \frac{60 \times 12{\cdot}5 \times 20}{100}:$$

Or suppose the spindle and screw-

Table of Change Wheels for Screw Cutting, the leading screw being of ½-inch pitch, or containing 2 threads in an inch.

Number of threads in inch of screw.	Numb. of teeth in		Number of threads in inch of screw.	Number of teeth in				Number of threads in inch of screw.	Number of teeth in			
	Lathe spindle-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.		Lathe spindle-wheel.	Wheel in contact with spindle-wheel.	Pinion in contact with screw-wheel.	Leading screw-wheel.
1	80	40	8¼	40	55	20	60	19	50	95	20	100
1¼	80	50	8½	90	85	20	90	19½	80	120	20	130
1½	80	60	8¾	60	70	20	75	20	60	100	20	120
1¾	80	70	9½	90	90	20	95	20¼	40	90	20	90
2	80	90	9¾	40	60	20	65	21	80	120	20	140
2¼	80	90	10	60	75	20	80	22	60	110	20	120
2½	80	100	10½	50	70	20	75	22½	80	120	20	150
2¾	80	110	11	60	55	20	120	22¾	80	130	20	140
3	80	120	12	90	90	20	120	23¾	40	95	20	100
3¼	80	130	12¾	60	85	20	90	24	65	120	20	130
3½	80	140	13	90	90	20	130	25	60	100	20	150
3¾	80	150	13½	60	90	20	90	25½	30	85	20	90
4	40	80	13¾	80	100	20	110	26	70	130	20	140
4¼	40	85	14	90	90	20	140	27	40	90	20	120
4½	40	90	14¼	60	90	20	95	27½	40	100	20	110
4¾	40	95	15	90	90	20	150	28	75	140	20	150
5	40	100	16	60	80	20	120	28½	30	90	20	95
5½	40	110	16¼	80	100	20	130	30	70	140	20	150
6	40	120	16½	80	110	20	120	32	30	80	20	120
6½	40	130	17	45	85	20	90	33	40	110	20	120
7	40	140	17½	80	100	20	140	34	30	85	20	120
7½	40	150	18	40	60	20	120	35	60	140	20	150
8	30	120	18¾	80	100	20	150	36	30	90	20	120

Table of the Diameters of Wheels—continued.

Pitch of the teeth in inches.																		
[illegible]	1¼		1⅜		1½		1⅝		1¾		1⅞		2 inch		2⅛		2¼	
Diameter at the pitch circle in feet and inches.																		
10¾	1	0	1	1⅛	1	2⅜	1	3½	1	4½	1	6	1	7⅛	1	8¼	1	9
11⅛	1	0⅜	1	1⅝	1	2⅞	1	4	1	5⅜	1	6½	1	7¾	1	9	1	10
11½	1	0¾	1	2	1	3⅜	1	4⅝	1	5⅞	1	7⅛	1	8⅜	1	9⅝	1	11
11⅞	1	1⅛	1	2½	1	3¾	1	5⅛	1	6½	1	7¾	1	9	1	10⅜	1	11
0⅛	1	1⅝	1	3	1	4¼	1	5⅝	1	7	1	8⅜	1	9⅝	1	11	2	0
0⅝	1	2	1	3⅜	1	4¾	1	6⅛	1	7½	1	9	1	10⅛	1	11¾	2	1
1	1	2⅜	1	3¾	1	5¼	1	6⅝	1	8	1	9½	1	10⅞	2	0⅜	2	2
1¼	1	2¾	1	4¼	1	5⅝	1	7¼	1	8⅝	1	10	1	11½	2	1	2	2
1⅝	1	3¼	1	4⅝	1	6¼	1	7⅝	1	9¼	1	10¾	2	0¼	2	1¾	2	3
2	1	3½	1	5	1	6⅝	1	8¼	1	9¾	1	11⅜	2	0⅞	2	2⅜	2	4
2⅜	1	4	1	5½	1	7⅜	1	8¾	1	10⅜	1	11⅞	2	1½	2	3	2	4
2¾	1	4⅜	1	6	1	7⅝	1	9¼	1	10⅞	2	0½	2	2⅛	2	3¾	2	5
3	1	4¾	1	6⅜	1	8	1	9¾	1	11½	2	1	2	2¾	2	4½	2	6
3½	1	5⅛	1	6⅞	1	8⅝	1	10¼	2	0	2	1⅝	2	3⅜	2	5	2	6
3¾	1	5⅝	1	7¼	1	9	1	10¾	2	0½	2	2¼	2	4	2	5¾	2	7

Table of the Diameters of Wheels—continued.

Pitch of the teeth in inches.									
1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2 inch	2⅛	2¼
Diameter at the pitch circle in feet and inches.									
4⅝	2 7¾	2 11	3 2¼	3 5⅜	3 8½	3 11¾	4 3	4 6⅛	4 9
5	2 8¼	2 11½	3 2⅝	3 5⅞	3 9⅛	4 0⅜	4 3½	4 6⅞	4 10
5⅜	2 8⅝	2 11⅞	3 3⅛	3 6⅜	3 9⅝	4 0⅞	4 4¼	4 7½	4 10
5¾	2 9	3 0⅜	3 3⅝	3 6⅞	3 10¼	4 1½	4 4⅞	4 8⅛	4 11
6	2 9⅜	3 0¾	3 4	3 7½	3 10¾	4 2⅛	4 5½	4 8⅞	5 0
6⅜	2 9¾	3 1¼	3 4½	3 7⅞	3 11¼	4 2¾	4 6⅛	4 9½	5 0
6¾	2 10¼	3 1⅝	3 5¼	3 8½	3 11⅞	4 3¼	4 6¾	4 10⅛	5 1
7⅛	2 10⅝	3 2	3 5½	3 9	4 0½	4 3⅞	4 7⅜	4 10⅞	5 2
7½	2 11	3 2½	3 6	3 9½	4 1	4 4½	4 8	4 11½	5 3
7⅞	2 11⅜	3 2⅞	3 6½	3 10	4 1½	4 5⅛	4 8⅝	5 0¼	5 3
8¼	2 11¾	3 3¼	3 7	3 10½	4 2⅛	4 5¾	4 9¼	5 0⅞	5 4
8½	3 0¼	3 3⅞	3 7½	3 11	4 2¾	4 6¼	4 9⅞	5 1½	5 5
8⅞	3 0⅝	3 4¼	3 7⅞	3 11⅝	4 3¼	4 7	4 10½	5 2⅛	5 5
9¼	3 1	3 4¾	3 8⅜	4 0⅛	4 3⅞	4 7½	4 11¼	5 2⅞	5 6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

is alike.

4. That when unguents are interposed, th of friction depends more upon the natu unguent than upon that of the surfaces of and hence, that the nature of the unguent to l must be governed by the pressure or insiste Mr. Rennie found, that with the unguents t anti-attrition, on axles under a pressure of 5 cwt., the friction did not exceed $\frac{1}{39}$th of pressure; but when softer unguents were a oil, hog's-lard, &c., the ratio of the fricti pressure considerably increased; from w naturally inferred that the consistence of a ought just to prevent the bodies coming in with each other.

5. That the friction of metals, without a unguent interposed, varies as their hardness metals producing less friction than the soft

6. That without unguents, and within th $32\frac{1}{3}$ lbs. pressure per square inch, the fricti metals upon hard metals may very general mated at about $\frac{1}{6}$th of the whole pressure.

7. That within the limits of their abrasio tion of metals is nearly alike; but from 1·

property, repeating ... number of times the end of the ram exceeds the ... of the pump.

Ex. Required the repulsive force of a 6-inch ... when a power of 50 lbs. is applied to the end o... lever, which is as 12 to 1 in effect, and the dia... of the pump or plunger $\frac{7}{8}$ths of an inch.

$$\frac{\text{Area of ram}}{\text{Area of pump}} = \frac{28{\cdot}2744}{{\cdot}6013} = 47;$$

and $50 \times 12 \times 47 = 28200$ lbs., or 12 tons nearly.

When a body is partly or wholly immersed in ... or other fluid, the vertical pressure of the fluid ... to raise the body with a force equal to the wei... the fluid displaced; hence the weight of an... placed quantity of a fluid by a buoyant body ... the weight of that body.

Ex. 1. Suppose a vessel with all its masts, ... and general equipments, is found to displace ... cubic feet of sea water, what is the whole we... the vessel?

Sea water average 64 lbs. per cubic foot.

$$\frac{35000 \times 64}{2240} = 1000 \text{ tons.}$$

and this contraction of the stream reduces t
of its section from 1 to ·619, or nearly ⅝ths
short parallel tube be attached, the vein of the
is less contracted, and the area will equal ·762
if the tube attached be the frustum of a cone
greater end is the aperture, the length equal l
diameter of the aperture, and the area of th
end to the area of the larger as 1 to 1·6, there
no contraction of the vein: hence the prop
making the pipe in this form from a reservoir c
head of water, through which the greatest q
according to its area, is required to pass.

*To find the velocity of water issuing throug
cular orifice at any given depth from the sur*

Rule.—Multiply the square root of the he
depth to the centre of the orifice by 8·1, and
duct is the velocity of the issuing fluid in
second.

Ex. Required the velocity of water issuing
an orifice under a head of 11 feet from the s

$\sqrt{11}=3{\cdot}3166 \times 8{\cdot}1=26{\cdot}864$ feet, velocity per se

either by making the stream of water a few inches narrower than the wheel, or otherwise.

3. That because of water producing a less efficient power by impulse than gravity, turbines, or machines through which the motion is obtained by reaction, are greatly preferable to undershot, or low breast wheels.

4. That a head* of water is required sufficient to cause the velocity of its flowing to be as 3 to 2 of the wheel; $\frac{1}{9}$th of the wheel's diameter being an approximate height, near enough for practical purposes.

5. That the effective power of a wheel constructed according to these restrictions is equal to the product of the number of cubic feet, and velocity in feet per minute, multiplied into ·001325.

Example for general illustration

Suppose a fall of water 25 feet in height, over which is delivered 112 cubic feet per minute; required the various peculiar requisites for a wheel to be in accordance with the preceding rules.

1st. $25 \times 1{\cdot}08 = 27$ feet, the wheel's diameter.

2nd. $\sqrt{25} \times 2 = 10$ feet, velocity of the wheel in ft. per second. Also $27 \times 2{\cdot}1 = 56{\cdot}7$, say 57 buckets.

3rd. $27 \div 9 = 3$ feet, head of water required.

4th. $112 \times 10 \times 60 \times {\cdot}001325 = 89$ horses' power.

The *turbine* of Fourneyron, in France, and the patented *Water-Mill* of Whitelaw and Stirrat, Scotland, have of late years attracted a considerable share of public attention, their simplicity of construction and asserted effects in like situations being equal to those of the best applied water-wheels. In their manner of construction, they differ, but in principle they are the same; the action of each being created by a centrifugal and tangential force, caused by the weight or impulsion of a column

* By head is meant the distance from the surface of the

in a right line with the

In 1838 a number of experiments were France by Morin, with a view to the mo introduction of turbines, and a positive pro merited qualities in preference to wheels c which terminated considerably in favour o and from which the following deductions w

1. That turbines are equally adapted to small falls of water.

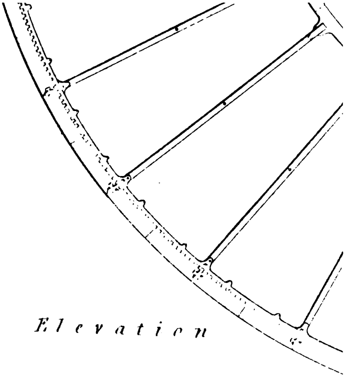
2. That they are capable of transmittin effect to from 70 to 78 per cent. of the absol

3. That their velocities may vary very cc from the maximum effect, without differin sibly from it.

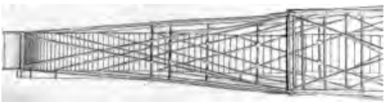
4. That they will work nearly as effect drowned to the depth of 5 or 6 feet, as whe consequently, they will make use of the w fall when placed below the level of extreme

5. That they may receive variable q water without altering the ratio of the pc effect. Corresponding results have also b by Whitelaw and Stirrat's machine: hei said of the one is equally applicable to th

General Rule by Mr. Whitelaw, whereby



Elevation



63	20·062	112	35·655	160	50·933	208	
64	20·380	113	35·974	161	51·251	209	
65	20·698	114	36·292	162	51·569	210	
66	21·016	115	36·611	163	51·888	211	
67	21·335	116	36·929	164	52·206	212	
68	21·653	117	37·247	165	52·524	213	
69	21·971	118	37·565	166	52·843	214	
70	22·289	119	37·883	167	53·161	215	
71	22·607	120	38·202	168	53·479	216	6
72	22·926	121	38·520	169	53·798	217	6
73	23·244	122	38·838	170	54·116	218	6
74	23·562	123	39·156	171	54·434	219	6.
75	23·880	124	39·475	172	54·752	220	7
76	24·198	125	39·793	173	55·071	221	7
77	24·517	126	40·111	174	55·389	222	7
78	24·835	127	40·429	175	55·707	223	7
79	25·153	128	40·748	176	56·026	224	71
80	25·471	129	41·066	177	56·344	225	71
81	25·790	130	41·384	178	56·662	226	71
82	26·108	131	41·703	179	56·980	227	72
83	26·426	132	42·021	180	57·299	228	72
84	26·741	133	42·339	181	57·617	229	72
85	27·063	134	42·657	182	57·935	230	73
86	27·381	135	42·976	183	58·253	231	73·
87	27·699	136	43·294	184	58·572	232	73·
88	28·017	137	43·612	185	58·890	233	74·
89	28·336	138	43·931	186	59·209	234	74
90	28·654	139	44·249	187	59·527	235	74·
91	28·972	140	44·567	188	59·845	236	75·
92	29·290	141	44·885	189	60·163	237	75·
93	29·608	142	45·204	190	60·482	238	75·
94	29·927	143	45·522	191	60·800	239	76·
95	30·245	144	45·840	192	61·118	240	76·
96	30·563	145	46·158	193	61·436	241	76
97	30·881	146	46·477	194	61·755	242	77·
98	31·200	147	46·795	195	62·073	243	77·
99	31·518	148	47·113	196	62·392	244	77·
100	31·836	149	47·432	197	62·710	245	77·
101	32·155	150	[illegible]				

For cross cutting, round or square timber,
principle of the stone mill, framed, with t
wheels, &c. ....

Steel, for wheat, barley, oats, peas, beans, &c
do. do. do.

Sugar, cattle, for the West Indies, &c. The r
strong iron frame. 5 feet long, and 2 feet di
work in a horizontal position, including the r
to work the mill, with the wood arms, sw
for the cattle to draw from, complete ......
rollers, 4½ feet long, and 2 feet diameter..
do. 4 do. 1⅞ do. ..
do. 3½ do. 1½ do. ..
do. 3 do. 1½ do. ..

Sugar, for a steam engine,
rollers, 5 feet long, and 2 feet diameter..
do. 4½ do. 2 do. ..
do. 4 do. 2 do. ..
do. 3½ do. 2 do. ..
do. 3 do. 2 do. ..

The machinery for connecting the en
mill, for working it, in addition .....

Sugar, for a windmill,
rollers, 5 feet long, and 2 feet diameter..
do. 4½ do. 2 do. ..
do. 4 do. 2 do. ..
do. 3½ do. 2 do. ..
do. 3 do. 2 do. ..

A pair of wheels to connect the spindle o
to the sugar mill, will be, in addition t
going ....

Sugar, for a water wheel,
rollers, 5 feet long, and 2 feet diameter..
do. 4½ do. 2 do. ..
do. 4 do. 2 do. ..
do. 3½ do. 2 do. ..
do. 3 do. 2 do. ..

The machinery to connect the sh

2				
2¼	16			
2½	20	[illegible]		
2¾	24	18½		
3	28	22½	8	
3¼	33	26½	8¼	226
3½	38	31½	8½	239
3¾	44	35½	8¾	252
4	50	40	9	267
4¼	57	45½	9¼	282
4½	64	51	9½	297
4¾	71	56½	9¾	312
5	78	62	10	331
5¼	86	69	10¼	350
5½	94	76	10½	36
5¾	103	83	10¾	38
6	112	90	11	4
6¼	122	98	11¼	4
6½	132	107	11½	
6¾	142	115	11¾	
7	153	124	12	

shafts, up to 2 inches, square or r
bearings, turned ....
2 inches to 2½ inches ....
2 do. 4 do. ....
2½ do. 6 do. ....
4 do. 9 do. ....
6 do. 12 do. ....
9 .do.

Where shafts are turned e
to the bearing at each en
blocks, such additional t
measured and charged at
tion to the price of the sh

Shafts, of wood, ...
elm, of all sizes............
fir do. ....
oak, up to 18 inches........
ditto 2 feet ....
the above includes mo
gudgeons.
measure the largest
the charging dimensio
urned ....
with staves.

	£	s.	d.
Millwright's Work,			
Water wheel work, &c.,			
oak starts, 3½ by 2 .... per foot run	0	1	6
floats and back boards of elm, prepared to size per foot super.	0	0	10
over shot wheels, rings, and arms ready made, the rings 8 in. wide and 3 in. thick .. per foot diam.	2	7	0
elm sole boards, risers, and buckets, per foot super.	0	0	10
wrought iron floats bent to order..... .... per lb.	0	0	10
Wheels, bevel, of wood, for the bevel, charge additional per foot	0	5	0
windmill brakes, 9 inches wide......per foot diam.	1	15	0
maltmill heads, with staves .... do.	8	0	0
wallowers, with ditto .... do.	8	17	0
spur nuts of elm, of 2 to 4 inch plank do.	8	10	0

the cogs, in all cases, to be charged extra.

Wheels, of cast iron, both tooth and mortis, geared, pitched, chipped and filed, the pattern included in the price.

width of cog,	pr. ft. diam.	width of cog,	per ft. diam.
1 inch	£3 3 0	8¾ inches......	11 12 6
1¼	3 5 0	9	12 0 0
1½	3 10 0	9¼	12 5 0
1¾	3 15 0	9½	12 10 0
2	4 0 0	9¾	12 15 0
2¼	4 5 0	10	13 0 0
2½	4 10 0	10¼	13 5 0
2¾	4 15 0	10½	13 10 0
3	5 0 0	10¾	13 15 0
3¼	5 5 0	11	14 0 0
3½	5 10 0	11¼	14 10 0
3¾	5 15 0	11½	15 0 0
4	6 0 0	11¾	15 10 0
4¼	6 7 6	12	16 0 0
4½	6 15 0	12¼	17 0 0
4¾	7 2 6	12½	18 0 0
5	7 10 0	12¾	19 0 0
5¼	7 12 6	13	20 0 0
5½	7 15 0	13¼	20 10 0
5¾	7 17 6	13½	21 0 0
6	8 0 0	13¾	21 10 0
6¼	8 5 0	14	22 0 0
6½	8 10 0	14¼	22 10 0
6¾	8 15 0	14½	23 0 0
7	9 0 0	14¾	23 10 0
7¼	9 7 6	15	24 0 0
7½	9 15 0	15¼	24 10 0
7¾	10 2 6	15½	25 0 0
8	10 10 0	15¾	25 10 0
8¼	10 17 6	16	26 0 0
8½	11 5 0		

Wheels, lantern, made solid, and fitted together in two pieces, or halves, with wrought iron hoops and copper screws, &c.

7 inches deep over all .... per foot diam.	7	0	0
8 do. .... do.	8	0	0
9 do. .... do.	9	0	0

width ....
foreign live oak, shanked as before ..
ditto, above 3 inches wide, extra per
width ....
for wood wheels, not exceeding 12 in.
addition to the foregoing prices ..
labour, shanking ....
patterns for wheels, all above 18 in.

width of cog,		pr. ft. diam.			width of cog,
1 inch	......	£0	9	6	7¾
1¼	......	0	9	9	8
1½	......	0	10	0	8¼
1¾	......	0	10	3	8½
2	......	0	10	6	8¾
2¼	......	0	10	9	9
2½	......	0	11	0	9¼
2¾	......	0	11	3	9½
3	......	0	11	6	9¾
3¼	......	0	11	9	10
3½	......	0	12	0	10¼
3¾	......	0	12	3	10½
4	......	0	12	6	10¾
4¼	......	0	12	9	11
4½	......	0	13	0	11¼
4¾	......	0	13	6	11½
5	......	0	14	0	11¾
5¼	......	0	14	6	12
5½	......	0	15	0	12¼
5¾	......	0	15	6	12½
6	......	0	16	0	12¾
6¼	......	0	16	6	13
6½	......	0	17	0	13¼
6¾	......	0	17	6	13½
7	......	0	18	0	13¾
7¼	......	0	18	6	14
7½	......	0	19	0	

riggers of wood,
above 20 inches diameter, single gro
made of 4-inch elm ... per f

10¾	....	8 9 0	13¾	....
11	....	8 10 0	14	....
11½	....	8 12 6		

pitching and trimming, including filing, p. in. measurement to be taken from the patte and not from the wheel.

wheels of wood,

a horse wheel, of any diam., 4 in. thick, per f
do. 5 do. do.
do. 6 do. do.
do. 7 do. do.
do. 8 do. do.

The cogs to be charged extra.

PRICES OF PORTABLE STEAM-ENGINE TUBULAR BOILERS COMPLETE

Horse-power.	Diameter of Cylinder.	Length of stroke.
1	3 inches.	6½ inches.
2	4½ "	9 "
3	5½ "	11 "
4	6½ "	13 "
5	7½ "	14 "
7	8½ "	14 "
9	9½ "	16 "
11	10¾ "	18 "
13	11¾ "	20 "
16	13 "	22 "
20	14½ "	24 "

The following formulæ, with some modification and improvement, are extracted from Nystrom's Mechanics, an American publication designed for the use of engineers. To render them more generally available to the practical workman, they are reduced, at page 268, &c., to the form of verbal rules, each of which is to be employed in connection with the figure to which the number prefixed to the rule refers.

HYDRAULICS.

Let the vessel *A*, Fig I., be kept constantly full of water up to the water line *w*. In two horizontal faces lower than the water line *w*, are made orifices *a* and *a'*, through which the water will pass up vertical nearly to the water line *w*. Omitting the resistance of air, &c., the jet should theoretically reach the water line *w*; practically it reaches $0 \cdot 967h$.

It is evident that the velocity of the *jet* through the orifices, must be the velocity due to a body falling the height *h*, according to the law of force of gravity.

Letters denote.

Q = actual quantity of water discharged per second or in the time *t*, in cubic feet.

h = head, or height of water over the orifice.

t = operating time in seconds.

a = area of the orifice in square feet.

m = the coefficient for contraction. (See Table, p. 261).

G = gallons of 277 cubic inches discharged in the time *t*.

V = velocity through the orifice in feet per second.

Example 1. Fig. I. How many gallons of will be discharged in five minutes, through

Fig. III. n = number of down
minute, s=stroke of piston ; the air ve
at the pressure of the atmosphere.

Example 2. Fig. III. How many d
must be made per minute by the lev
pump, to throw up 22 cubic feet of w
high, in the time of 8 minutes and
the lever $l = 30$ inches, $e = 8$ inches,
$F = 20$ pounds ? $8 \times 60 + 15 = 495$ se

$$n = \frac{3630\,Q\,h'\,e}{t\,s\,F\,l} = \frac{3630 \times 22 \times 18 \times 8}{495 \times 0{\cdot}6 \times 20 \times 30} = 64{\cdot}5 \text{ st}$$

Example 3. Fig. XI. A vessel
form is of dimensions $A = 6$ square f
$h = 5$ feet. What time will it take t
to sink 2 feet, when the orifice $a =$
feet ?

$$t = \frac{A\,(\sqrt{h} - \sqrt{h'})}{4 \times {\cdot}64\,a} = \frac{6\,(\sqrt{5} - \sqrt{3})}{2{\cdot}56 \times {\cdot}212}$$

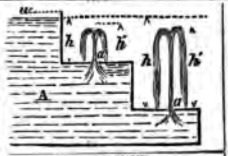
MOTION OF WATER IN PI

Letters denote.

L = extreme length of the pipe in
d = inside diameter in feet, and u
out the length L.

diameter, and $L=68$ feet long, the head pressure of water being $h=8$ feet?

$$V=48\sqrt{\frac{0{\cdot}45\times 8}{68+50\times 0{\cdot}45}}=9{\cdot}6 \text{ feet per second.}$$



I.

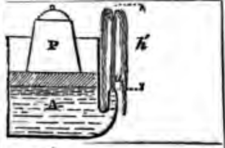
$$V=8{\cdot}02\sqrt{h}$$

$$Q=m\,a\,t\,8{\cdot}02\sqrt{h}=5{\cdot}05\,a\,t\sqrt{h}$$

$$G=31{\cdot}5\,a\,t\sqrt{h},\quad m=0{\cdot}63,$$

$$jet=0{\cdot}967h,$$

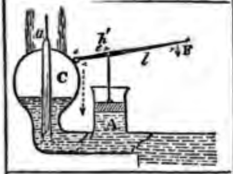
$$h=\frac{Q^2}{25{\cdot}5\,a^2\,t^2},\quad =h'.$$



II.

$$V=1{\cdot}015\sqrt{\frac{P}{A}},\ Q=a\,t\sqrt{\frac{P}{A}},$$

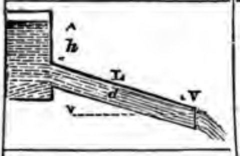
$$G=6{\cdot}2\,a\,t\sqrt{\frac{P}{A}},\ h'=\frac{P}{64{\cdot}6A}.$$



III.

$$Q=a\,t\sqrt{\frac{F\,l}{A\,e}},\ n=\frac{3630\,Q\,h'\,e}{t\,s\,F\,l},$$

$$G=6{\cdot}2\,a\,t\sqrt{\frac{F\,l}{A\,e}},\ h'=\frac{F\,l}{64{\cdot}6\,A\,e}.$$

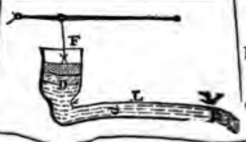


IV.

Motion of Water in Pipes.

$$V=48\sqrt{\frac{d\,h}{L+50d}},\ Q=37{\cdot}7\,d^2\sqrt{\frac{d\,h}{L+50d}},$$

$$d=0{\cdot}24\sqrt[5]{\frac{L\,Q^2}{h}},\quad h=\frac{Q^2\,(L+50d)}{1421\,d^5}.$$



V.

Motion of Water in Pipes.

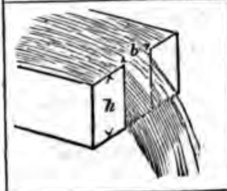
$$V=6.86\sqrt{\frac{d\,F}{D(L+50d)}},\ Q=5{\cdot}38\,d^2\sqrt{\frac{d\,F}{D(L+5}}$$

$$d=1{\cdot}68\sqrt[5]{\frac{L\,D\,Q'}{F}},\quad F=\frac{Q^2\,D(L+50}{29d^5}$$

Weirs.

$Q = k\,b\,t$. See Table for *We*

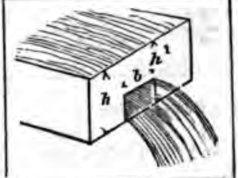
$$t = \frac{Q}{k\,b}, \qquad b = \frac{Q}{k\,t}$$



VIII.

$$Q = 5{\cdot}35m\,b\,h\,t\sqrt{h}$$
$$G = 33m\,b\,h\,t\sqrt{h},$$

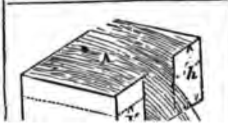
$$t = \frac{Q}{5{\cdot}35\,m\,b\,h\,\sqrt{h}}$$



IX.

$$Q = 5{\cdot}35m\,b\,t\,(h\sqrt{h} - h$$
$$G = 33m\,b\,t(h\sqrt{h} - h'$$

$$t = \frac{Q}{5{\cdot}35m\,b(h\sqrt{h} - h'}$$



X.

$$t = \frac{0{\cdot}95m\,A\,(\sqrt{h} -}{b\sqrt{h\,h'}}$$

A = area of the vessel in sq

Example 5. Fig. VI. Required the ᐧ quantity of water discharged in a long p of $L=135$ feet long, and $d=0\cdot17$ feet, a hand-pump of $D=0\cdot2$ feet in diam pounds, and the end of the pipe elevated above the piston D?

$$V=6\cdot86\sqrt{\frac{0\cdot17(44-49\times0\cdot2^2\times20)}{0\cdot2(135+50\times0\cdot17)}}=1\cdot95 \text{ fee}$$

$Q=1\cdot95\times5\cdot38\times0\cdot2^2=0\cdot042$ per second × 6 feet per minute.

$s=0\cdot8$ feet the stroke of piston, we shall ha

$$n=\frac{2\cdot52}{0\cdot8\times0\cdot785\times0\cdot2^2}=100 \text{ strokes pe}$$

TABLE FOR WATER FLOWING OVE

This Table is set up from careful ex a large scale, and is suited for *weir* Fig. VII.

h. inches.	*h. feet.*	*m.*	*k.*
0·4	0·033	0·424	0·013[illegible]
0·8	0·066	0·417	0·054[illegible]
1·2	0·100	0·412	0·1059
1·6	0·133	0·407	0·166[illegible]
2·4	0·200	0·401	0·291[illegible]
3·2	0·266	0·397	0·444
4·	0·333	0·395	0·631
[illegible]	0·500	0·393	1·129

Rule. Multiply the width b in feet, of the *weir*, by the coefficient k, and the product is the quantity of water discharged per second, in cubic feet. h is the height as represented by Fig. VII. The width b should be $b > h$.

Example 6. How much water will flow over a weir of $b=5$ feet, $h=0{\cdot}5$ feet in one minute?

$$Q = k\,b\,t = 1{\cdot}1295 \times 5 \times 60 = 338{\cdot}35 \text{ cubic feet.}$$

HYDRODYNAMICS.—WATER POWER.

The natural effect concentrated in a fall of water, is equal to the weight of the quantity of water passed through per second multiplied by the vertical space it falls.

Fig. XII. Let Q be the quantity of water which passes through the orifice a in the time $t = 1$ second, in cubic feet of 62·5 pounds each.

$h =$ the vertical space the water falls; then the value or natural effect of the fall is at the orifice a,

$$P = 62{\cdot}5\,Q\,h, \text{ effects.}$$

But, $Q = 5{\cdot}06 a\sqrt{h}$, then we have

$$P = 315{\cdot}5\,a\,h\sqrt{h}.$$

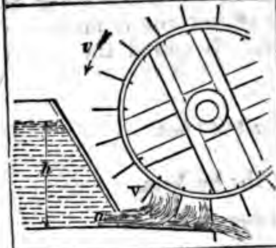
This will be in horse-power,

$$H = 0{\cdot}573\,a\,h\sqrt{h}, \qquad h = \frac{1}{1{\cdot}07}\sqrt[3]{\frac{H^2}{a^2}},$$

$$H = 0{\cdot}1134 Q\,h, \qquad h = \frac{H}{0{\cdot}1134\,Q}.$$

Example 1. In a creek passes 18 cubic feet of water per second. How high must that creek be dammed up to produce an effect of 10 horses?

$$h = \frac{10}{0{\cdot}1134 \times 18} = 4{\cdot}9 \text{ feet, the answer.}$$



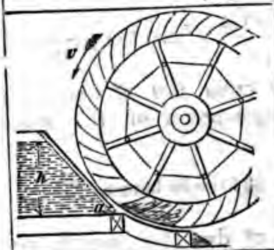
XVII.

Undersh

$H = \frac{Q v}{454}$

$H = \frac{m a v}{86{\cdot}8}$

When $V = 2v$, al



XVIII.

Poncel

$H = \frac{Q v}{228}(V -$

$H = \frac{Q v}{197}(V -$

$Q = 8ma\sqrt{h},$

XIX.

Breast-Wheel

number ·62, the product ...
issue.

For the number of cubic feet dischar... number of seconds.—Rule: Multiply the ... orifice in square feet by the number of s... the product by 5·05 times the square roo... of the head of water.

For the number of gallons discharg... Multiply the area of the orifice by the ... seconds, and the product by 31·5 times ... root of the height of the head.

For the height of the head of wat... Divide the number of cubic feet discha... time by 5·05 times the area of the orifi... by the number of seconds in that time ... of the quotient will be the height in feet.

Note.—To allow for the resistance of the ... the height of the head of water should be ... ·967; the product is the height of the jet.

II. *Velocity.*—Rule: Let the ... column of water which, pressing on ... would produce the jet, be expressed ... divide the number of these pounds b...

Divide the former product by the ... quotient will be the height of the jet pressure on A.

RULES FOR THE MOTION OF WATER

IV. *For the velocity of delivery.*—Ru[le] the inner diameter of the pipe in feet by [t] feet of the head of water above the point Add the entire length of the pipe in feet the inner diameter. Divide the former the sum. Extract the square root of and multiply that root by 48.

For the cubic feet delivered in a sec[ond] Take the square root found above, an[d] by 37·7 times the square of the dia[meter of the] pipe; the product will be the number discharged in a second.

For the diameter of the pipe.—Ru[le] the square of the number of cubic f[eet] found as above, by the length of the pi[pe] product by the height of the head abov[e] delivery; take the *fifth* root of the multiply it by ·24; the product will

meter, and multiply the sum by the square of the number of cubic feet discharged in a second. Divide the product by 1421 times the fifth power of the diameter; and the quotient will be the height of the head.

V. *For the velocity of the discharge.*—RULE: Multiply the force in pounds acting on the piston by the inner diameter of the pipe. Multiply the length of the pipe increased by 50 times its diameter by the diameter of the piston—all the measures being taken in feet. Divide the former product by the latter, and multiply the square root of the quotient by 6·86; the product will be the velocity per second in feet.

For the cubic feet delivered per second.—RULE: Multiply the square root, found as above, by 5·38 times the square of the inner diameter of the pipe in feet; the product will be the number of cubic feet delivered.

For the diameter of the pipe.—RULE: Multiply together the length of the pipe, the diameter of the piston, and the square of the number of cubic feet discharged per second. Divide the product by the force in pounds acting on the piston, and multiply the *fifth* root of the quotient by 1·68; the product will be the diameter in feet.

For the force applied to the piston.—RULE: Multiply the length of the pipe increased by 50 times its diameter by the diameter of the piston, and by the square of the number of cubic feet delivered in a second. Multiply the fifth power of the diameter of the pipe by 29. Divide the former product by the latter; the quotient will be the force in pounds acting on the piston.

product by this, and multiply the square r
quotient by 6·86; the result will be the v
second of the issuing water.

For the cubic feet delivered.—RULE:
together the velocity determined as above,
of the inner diameter of the pipe, the
seconds in the time, and the number 5·38
duct will be the number of cubic feet d
that time.

*For the height above the end of the pi
the water spouts.*—RULE: Divide the squ
issuing velocity by 66·5, the quotient w
height in feet, allowing for the resistance

Or, multiply the number of strokes per
the length of the stroke, and the square
product by the diameter of the piston: the
result by 57·65 times the inner diameter

For the number of strokes of the piston
(see ex. 5).—RULE: Multiply together
of the stroke, the square of the diam
piston, and the number ·785, and divide
of cubic feet discharged per *minute* by th

RULES FOR WEIRS (See the Table,

VII. *For the cubic feet discharged in*

of seconds ...
table, and the number 5·35. The pr
five numbers will be the number of
charged.

For the number of gallons discha
Take the product of the first *four* c
multiplied together in the preceding r
of the fifth multiplier there used, e
tiplier 33; the product of the five n
the number of gallons discharged in t

For the time of discharging a gi
cubic feet.—RULE: Multiply the
water-level above the bottom of the is
the square root of that height. Mul
of the water-level above the top of th
by the square root of that height.
product from the former. Multipl
by the width of the aperture, the
the table, and the number 5·35. D
of cubic feet discharged by this
quotient will be the number of seco

X. *For the time in which th*
sink through a given space.—I
... root of the entire height

area of the surface of the inclosed water in square feet, by the number m from the table, and by the number ·95. Multiply the square root of the product of the two heights by the width of the aperture. Divide the former product by the latter, and the quotient will be the number of seconds in the time.

XI. *For the time in which the water level will sink through a given space.*—RULE: From the square root of the height of the vessel subtract the square root of the height of the water level after sinking the proposed space. Multiply the remainder by the area of the water surface, and divide the product by four times the area of the orifice multiplied by m taken from the table.

For the number of cubic feet discharged in this time.—RULE: Add the two square roots instead of subtracting them as above, and multiply the sum by four times the area of the orifice, by the number of seconds, and by the number m from the table.

Or, multiply the difference of the two heights by the area of the water surface, or of the bottom of the vessel; the product will be the number of cubic feet discharged.

RULES FOR THE SHORT DRAIN.

XII. *For the velocity at the orifice or entrance* c *the drain.*—RULE: Multiply the square root of t height of the water-level above the orifice by 8. Divide 1 by m, taken from the table, subtra from the quotient, and take the square of th mainder; increase this square by 1, and then the square root of the sum. The before-foun

square of it. Add ...
height of the orifice above the mouth ...
and take the square root of the sum.

*For the number of cubic feet disch...
time.*—RULE: Multiply together the ...
orifice, the area of the orifice, the num...
in the time, and the number m taken ...

NOTE.—The length of this drain is ab...
square root of the area of the orifice.

RULES FOR THE LONG DR...

XIII. *For the velocity at the orifi...
the drain.*—RULE; As the length o...
nothing to do with the velocity with
enters it, the RULE will obviously be
given above for the short drain.

For the velocity with which the w...
RULE: To the square of the veloc...
water enters the drain, add 64·32
of the point of entrance above tha...
note the sum. Add the width of
the depth of water flowing alo...
... the length of the drain, ...

RULES FOR THE PARABOLIC VEIN.

XIV. *For the horizontal distance spouted on any plane.*—RULE: Multiply together the height of the water-level above the orifice, and the height of the orifice above the horizontal plane, and take twice the square root of the product.

For the velocity with which the water strikes the horizontal plane.—RULE: Add together the two heights mentioned above, and take eight times the square root of the sum.

For the number of cubic feet discharged in any time.—RULE: Multiply together the area of the orifice, the seconds in the time, the square root of the height of the orifice above the water level, and eight times the number *m* taken from the table for the contracted vein.

For the height of the head of water above the orifice necessary to cause the water to spout a given distance on a given horizontal plane.—RULE: Divide the square of the given distance by four times the height of the orifice above the given plane; the quotient will be the height of the head.

XV. The rules for the velocity and number of cubic feet discharged are the same as in the former case.

RULES FOR WATER WHEELS, FROM THE FORMULÆ.

XVI. *For the horse-power of the under-shot wheel in mid stream.*—RULE: Subtract the velocity of the wheel from the velocity of the stream. Multiply the square of the remainder by the area of the float and the velocity of the wheel. Divide the product by 200; the quotient will be the horse-power.

For the horse-power when the wheel moves with

issuing stream and that of the
velocity, and also by the number of
water acting on the wheel per second
product by 454, the quotient will
power. RULE 2: Multiply the diff
velocities by the velocity of the whee
the aperture, the square root of the
head of water, and the number *m* ta
table for the vein, and divide the prod

*For the horse-power when the ve
issuing stream is double that of the w*
Multiply together the area of the
height of the head, and the square
height. Divide the product by ·47
will be the horse-power.

XVIII. *For the horse-power when
head of water exceeds five feet.*—R
the difference of the velocities by the
wheel and the number of cubic feet
upon it per second; and divide the

When the height of the head is less
RULE: Proceed as above, using, he
ber 197 for the divisor instead of 2
... of cubic feet of wa

and divide the product by 21·5. Add the height of the head above the lowest bucket to the result, multiply the sum by the number of cubic feet acting on the buckets in a sec., and divide the result by 13·7.

For the number of revolutions per minute.—RULE: Divide 100 by the diameter of the wheel, or distance between the centres of pressure of opposite buckets. Add 35 to the quotient, and the sum will express the number of revolutions per minute.

RULES FOR THE SAW-MILL WHEEL.

XXIII. *For the horse-power.*—RULE: Multiply the difference between the velocity of the water acting on the wheel and the velocity of the wheel itself by the latter velocity, and by the number of cubic feet acting on the buckets in a sec. Divide the result by 200; the quotient will be the horse-power.

For the proper diameter of the wheel.—RULE: Multiply the square root of the height of the head of water above the lowest bucket by 100, and divide the product by the number of revolutions per minute.

Effects produced by water in an aëriform state.

When water in a vessel is subjected to the action of fire, it readily imbibes the heat of which the fire is the cause, and sooner or later attains a temperature of 212° Fahrenheit. If at this temperature the water be not enclosed, but exposed to atmospheric pressure, ebullition will take place, and steam will ascend through the water, carrying with it the superabundant heat. Water, in attaining the aëriform state, thus obeys the same laws under every degree of pressure; but as the pressure is augmented, so is the indicated temperature proportionately raised; hence the various densities of steam, and degrees of elastic force.

15	6·80	30·60	[illegible]	[illegible]	[illegible]	
16	7·26	32·64	·829	216·3	81·9	102·4
17	7·71	34·68	·880	219·6	83·3	104·2
18	8·16	36·72	·932	222·7	84·7	105·9
19	8·62	38·76	·984	225·6	86·0	107·6
20	9·07	40·80	1·037	228·5	87·3	109·2
21	9·52	42·84	1·089	231·2	88·5	110·7
22	9·98	44·88	1·140	233·8	89·7	112·1
23	10·43	46·92	1·192	236·3	90·8	113·5
24	10·88	48·96	1·244	238·7	91·9	114·8
25	11·34	51·00	1·296	241·0	93·0	116·1
26	11·79	53·04	1·348	243·3	93·9	117·4
27	12·25	55·08	1·400	245·5	94·9	118·6
28	12·70	57·12	1·452	247·6	95·8	119·8
29	13·15	59·16	1·503	249·6	96·7	120·9
30	13·61	61·21	1·555	251·6	97·6	122·0
31	14·06	63·24	1·607	253·6	98·5	123·1
32	14·51	65·28	1·659	255·5	99·3	124·2
33	14·97	67·32	1·711	257·3	100·1	125·2
34	15·42	69·36	1·763	259·1	100·9	126·2
35	15·87	71·40	1·814	260·9	101·7	127·2
36	16·33	73·44	1·866	262·6	102·5	128·1
37	16·78	75·48	1·918	264·3	103·2	129·1
38	17·23	77·52	1·970	265·9	104·0	129·9
39	17·69	79·56	2·022	267·5	104·7	130·8
40	18·14	81·60	2·074	269·1	105·4	131·7
41	18·59	83·64	2·126	270·6	106·0	132·6
42	19·05	85·68	2·178	272·1	106·7	133·4
43	19·50	87·72	2·229	273·6	107·4	134·2
44	19·96	89·76	2·281	275·0	108·0	135·0
			[illegible]	[illegible]	108·6	135·8

The preceding Table is peculiarly adapted for estimating the power of steam engines on the condensing principle, because in such the effective force of the steam is the difference between the total force and the resisting vapour retained in the condenser. The following Table is more adapted for estimating the effects of non-condensing engines, as, in such, the atmospheric pressure is not generally taken into account, engines of this principle being supposed to work in a medium; or, the atmospheric pressure on the boiler, to cause a greater density of steam, is equal to the resisting atmosphere which the effluent steam has to contend with on leaving the cylinder.

Table of the Elastic Force of Steam, the Pressure of the Atmosphere not being included.

Elastic Force in			Temperature in degrees of Fahr.	Volume of Steam Water being 1.	Cubic in. of Water in a cubic foot of Steam.
Atmosphere.	lbs. ℔ sq. in.	in. of Merc.			
1·19	2·5	5·15	220	1496	1·14
1·22	3	6·18	222	1453	1·18
1·29	4	8·24	225	1366	1·25
1·36	5	10·3	228	1282	1·33
1·70	10	20·6	240	1044	1·64
2·04	15	30·9	251	883	1·93
2·38	20	41·2	260	767	2·23
2·72	25	51·5	268	678	2·52
3·06	30	61·8	275	609	2·81
3·40	35	72·1	282	553	3·09
3·74	40	82·4	288	506	3·38
4·08	45	92·7	294	468	3·66
4·42	50	103·0	299	435	3·93
4·76	55	113·3	304	407	4·20
5·10	60	123·6	309	382	4·48

Steam, independent of the heat indicated by an immersed thermometer, also contains heat that cann

xistence on variou... be ... at 178° ...
roduced on various ... 212°, be ...
weight of steam at 212°, the result is water at 178 ... from
water at 62°, the result is water has received from
each of the nine parts of water has received the steam
steam 116·6° of heat, and consequently the steam
diffused or given out $116 \cdot 6 \times 9 = 1049 \cdot 4 - 3$...
1016° of heat which it must have contained. A...
it is ascertained by experiment, that if one ga...
water be transformed into steam at 212°, an...
steam allowed to mix with water at 52°, th...
will be raised to the boiling point, or 212°.
these and other experiments, it is ascertained
latent heat in steam varies from 940° to 1...
ratio of accumulation advancing from 21...
steam becomes more dense and of grea...
force: hence the severity of a scald by ste...
by boiling water.

It is because of the latent heat in stea...
in an aëriform state, that it becomes of s...
service in *heating*, *boiling*, *drying*, &c. ...
ing of buildings, its *economy*, *efficie*...
plicity of *application*, are alike ackno...
steam being simply conducted through...
ments by pipes, by extent of circula...
...tent heat being thus given t...
...diation. In boiling, ...dvantage

Steam is also of great utility as a productive source of motive power; and in this respect its properties are *elastic force*, *expansive force*, and *reduction* by *condensation*. Elastic force signifies the whole urgency or power the steam is capable of exerting with undiminished effect. By expansive force is generally understood the amount of diminishing effect of the steam on the piston of a steam engine, reckoning from that point of the stroke where the steam of uniform elastic force is cut off; but it is more properly the force which steam is capable of exerting when expanded to a known number of times its original bulk. And

Condensation, here understood, is the abstraction or reduction of heat by another body, and consequently not properly a contained property of the steam, but an effect produced by combined agency, in which steam is the principal; because any colder body will extract the heat and produce condensation, but steam cannot be so beneficially replaced by any other fluid capable of maintaining equal results.

The rules formed by experimenters as corresponding with the results of their experiments on the elastic force of steam at given temperatures vary, but approximate so closely that the following rule, because of being simple, may in practice be taken in preference to any other.

Rule.—To the temperature of the steam in degrees of Fahrenheit, add 100, divide the sum by 177, and the 6th power of the quotient equal the force in inches of mercury.

Ex. Required the force of steam corresponding to a temperature of 312°.

$$\frac{312+100}{177}=2{\cdot}3277^6=159 \text{ inches of mercury.}$$

When steam of a uniform elastic force is (
throughout the whole ascent or descent of th
the amount of effect produced is as the qu
steam expended. But let the steam be sh
any portion of the stroke, say, for instance
half, it expands by degrees until the termi
the stroke, and then exerts half its origin
hence an accumulation of effect in proportio
quantity of steam.

Rule.—Divide the length of the stroke by
tance or space into which the dense steam is a
and find the hyperbolic logarithm of the quo
which add 1, and the sum is the ratio of the

Ex. Suppose an engine with a stroke of 6 f
the steam cut off when the piston has moved
2; required the ratio of gain by uniform and
sive force.

$6 \div 2 = 3$; hyperbolic logarithm of $3 = 1{\cdot}0986 + 1$
ratio of effect; that is, supposing the whole effe
steam to be 3, the effect by the steam being c
$\frac{1}{3} = 2{\cdot}0986$.

Again, let the greatest elastic force of steam
cylinder of an engine equal 48lbs. per squar
and let it be cut off from entering the cylinde
the piston has moved $4\frac{1}{2}$ inches, the whole

Table of Hyperbolic Logarithms.

No.	Logrthm.	No.	Logrthm.	No.	Logrthm.	No.	Logrthm.
$1\frac{1}{4}$	·22314	$3\frac{1}{2}$	1·25276	$5\frac{3}{4}$	1·74919	8	2·07944
$1\frac{1}{2}$	·40546	$3\frac{3}{4}$	1·32175	6	1·79175	$8\frac{1}{2}$	2·14006
$1\frac{3}{4}$	·55961	4	1·38629	$6\frac{1}{4}$	1·83258	9	2·19722
2	·69314	$4\frac{1}{4}$	1·44691	$6\frac{1}{2}$	1·87180	$9\frac{1}{2}$	2·25129
$2\frac{1}{4}$	·81093	$4\frac{1}{2}$	1·50507	$6\frac{3}{4}$	1·90954	10	2·30258
$2\frac{1}{2}$	·91629	$4\frac{3}{4}$	1·55814	7	1·94591	12	2·48490
$2\frac{3}{4}$	1·01160	5	1·60943	$7\frac{1}{4}$	1·98100	14	2·63905
3	1·09861	$5\frac{1}{4}$	1·65822	$7\frac{1}{2}$	2·01490	16	2·77258
$3\frac{1}{4}$	1·17865	$5\frac{1}{2}$	1·70474	$7\frac{3}{4}$	2·04769	18	2·89037

In regard to the other case of expansion: When the temperature is constant the bulk is inversely as the pressure: thus, Suppose steam at 30 lbs. per square inch, required its bulk to that of original bulk, when expanded so as to retain a pressure equal to that of the atmosphere, or 15 lbs.

$$\frac{15+30}{15}=3 \text{ times its original bulk.}$$

Condensation of steam for motive purposes, generally, is effected by cold water, the quantity of which may be estimated by the following rule. From 1000 plus the temperature of the steam, subtract the required temperature of the condensed water, divide the remainder by the temperature of the condensed water minus the temperature of the cold or condensing water, and the quotient equal the number of times that the quantity, for condensation, must exceed that by which the steam is formed.

Ex. Required the ratio or quantity of water for condensation to 1 of water for the formation of steam, the temperature of the steam being 220°, and the required temperature of condensed water 180°.

$$\frac{1000+220-180}{180-52}=8 \text{ times the quantity.}$$

Salts in sea water.		3·03
Sulphate of soda	In common water.	31·5
Sulphate of iron		64
Alum		52
Sulphate of lime		45
Sulphate of magnesia ...		57·5
Muriate of soda		30
Nitrate of soda............		60
Acetate of soda............		60

Elastic Force of Steam in Inches of Me

Common water } boiling point, 212° F. { elastic fo
Sea water ...... } at 212 „ { „

Common water } boiling point, 216° F. { elastic fo
Sea water ...... } at 216 „ { „

Common water } boiling point, 220° F. { elastic fo
Sea water ...... } at 200 „ { „

Hence the propriety of procuring, for st
in its purest state.

3. *Effects produced by air in its natura in a rarefied state.*

The weight or pressure of the atmosphe

2	·136	·0218		
2¼	·172	·0276	8¼	2·314
2½	·212	·0340	8½	2·456
2¾	·257	·0412	8¾	2·603
3	·306	·0490	9	2·754
3¼	·359	·0576	9¼	2·909
3½	·416	·0668	9½	3·068
3¾	·478	·0766	9¾	3·232
4	·544	·0872	10	3·400
4¼	·614	·0985	10¼	3·572
4½	·688	·1104	10½	3·748
4¾	·767	·1230	10¾	3·929
5	·850	·1363	11	4·114
5¼	·937	·1503	11¼	4·303
5½	1·028	·1649	11½	4·496
5¾	1·124	·1803	11¾	4·694
6	1·224	·1963	12	4·896
6¼	1·328	·2130	12½	5·312
6½	1·436	·2304	13	5·746
6¾	1·549	·2489	13½	6·196
7	1·666	·2672	14	6·664
7¼	1·787	·2866	15	7·650
7½	1·912	·3067	16	8·704
7¾	2·042	·3275	18	11·016

Examples illustrative of the Utility of the

1. Required the quantity of water lifte

of the bucket of a 9½-inch pump,

1	1·47	·005	Hardly perceptil
2	2·93	·020	Just perceptible.
3	4·40	·044	
4	5·87	·079	Gentle pleasant w
5	7·33	·123	
10	14·67	·492	Pleasant brisk g
15	22·00	1·107	
20	29·34	1·968	Very brisk.
25	36·67	3·075	
30	44·01	4·429	High winds.
35	51·34	6·027	
40	58·68	7·873	Very high.
45	66·01	9·963	
50	73·35	12·300	A storm or tem
60	88·02	17·715	A great storm.
80	117·36	31·490	A hurricane.

In order to gain the greatest amount of the w impulsive effect to produce rotary or circular m by the sails of a wind-mill, the total surface o sails presented to the wind ought to be about $\frac{7}{8}$ t the circle's surface which is formed by their m and each sail angled to the plane of motion as fol the whip or back being divided into six equal p

Distance from centre of motion	1	2	3	4	5	6	Sme
Angle with plane of motion...	18°	19	18	16	12½	7	r
By G. Forrester, Liverpool	21°	21	18	14	9	3	

per minute, ...

per square inch above the pressure ...

$$\frac{375 \times 4{\cdot}5 \times 224}{1282} = 295$$ square feet nearly; the fire-gr

in accordance with the following rule.

Multiply the number of square feet of heat face by ·12, the product equal the area of fi in square feet, thus :

$295 \times {\cdot}12 = 35{\cdot}4$ square feet of furnace-bar.

Note.—By effective heating surface is meant horiz faces over fire, flame, or heated air; vertical or side requiring about 1¾ ft. to equal in effect 1 of horizonta

2. *To determine the proper dimensions for a shaped boiler, when the amount of effectiv surface in square feet is obtained by the rule.*

1. The bottom surface equal half the who
2. The length of the boiler equal twice t root of bottom surface.
3. The width equal one-fourth the lengt
4. The height equal one-third the lengt

Ex. Required the dimensions for a bo waggon form that may present an effect surface of 295 square feet.

... 147·5 square

per square inch, equ
add about $\frac{1}{8}$th of the quotient, or 217·8, for vertical surface, equal 1960·2 square feet engine,—thus nearly corresponding with *the* quantity of heating surface.

Note.—In the four boilers there are 608 brass tub in length and 3 inches in diameter. The length of place is 5 feet 10 inches, and breadth 2 feet 10; ·56 of a square foot of fire-bar to each cubic foot o capacity, and ·16 of a square foot of tube apertu square foot of fire-bar, the openings of the tu reduced by the thickness of the tube hoops. The of each chimney, of which there are two, is 3 feet

Locomotive Boilers, in the manner of t struction, are a class which, of necessity, de utmost degree of qualified attention, becau great pressures they are required to sustain unavoidably narrow limits in which such vas of steam are required to be generated.

In boilers of this description, it is of essential consequence that the water spac fire-box be of a sufficient width, say, on the sides, not less than $2\frac{3}{4}$ to 3 inches, and in where the tendency of the fire is urged by of the blast-pipe, at least $3\frac{1}{2}$ inches.

The boiler which I have selected for i

pecified particulars relative to the Boiler and Engine.

Diameter of cylinders		14 inches.
Length of stroke		18 „
Lap of the valve		1 „
Diameter of driving wheels		5½ feet.
Length of internal fire-box	2 feet	11½ inches.
Width of ditto	3 „	5 „
Length of cylindrical part of boiler	8 „	8 „
Diameter of ditto	3 „	4½ „
Length of tubes	8 „	11½ „
Number of tubes	133, of brass.	
Interior diameter of ditto		1¾ inches.
Diameter of blast-pipe		4 „

About 112 lbs. of coke consumed in this boiler vaporate 84 gallons of water; and from 20 to 25 lbs. f coke are consumed per mile.

Heating Powers of Combustible Substances.

Species of combustible.	lbs. of water heated from 32° to 212°.	lbs. of boiling water evaporated by 1 lb. of fuel.	lbs. of atmospheric air to each lb. of fuel.
Wood in its ordinary state	26	4·72	4·47
Wood charcoal..............	73	13·37	11·46
Coal	60	10·90	9·26
Coke	65	11·81	11·46
Turf	30	5·45	4·60
Turf charcoal	64	11·63	9·86

In regard to the giving of an order for a steam ngine of any required number of horses' power, it as been argued and ultimately decided, that in a ommercial point of view the order is not sufficiently ompleted by the dimensions of cylinder, boiler, &c. eing of ample magnitude to produce the specified ynamical effect in horses' power; and not unless coresponding with the established custom by Boulton nd Watt, or *that* of other manufacturers of equally ell known respectability: hence, generally, the fol-

[redacted]

[redacted]

The Improved Steam Hammer, of which
ntispiece is an accurate engraving, manufact
Paragon Works, near South Queensferry, Scot
have much pleasure, by the aid of a friend, of
escribing :

These Hammers are made of all sizes from 7
pwards, and are self-acting or can be wrough
and; and the great advantages of these hammer
heir substantiality, simplicity, and almost imp
bility of getting deranged in any of their p
combined with great moderation in price. The
Valve is of a peculiar description, for besides bei
balance valve, thereby reducing the friction o
face to the lowest possible point, it is so arra
that after the steam has been admitted to the u
side of the piston to raise the hammer, the
steam (before it is allowed to exhaust to th
mosphere) is led to the upper side of the pistor
thereby an addition to the blow or impetus is
to the hammer, from one-third to one-fifth
than its actual weight or gravity: this is ac
by using a very thick piston rod, the area of
piston rod is deducted from the under area
thereby showing the area of the upper

and if you are working with 30 ℔ steam, you have 585℔ minus expansion in favour of the upper side of your piston to bring down the hammer. The Piston is solid (*no packing*): the Piston Rod is of unusual thickness, of malleable iron, as is also the cross head, and these with the hammer and hammer-face make up the weight required. As mentioned, the Hammer is self-acting, and this is arranged as follows: upon the cross head there is a conical roller (case-hardened), which roller acts upon a spiral incline, also case-hardened, and bolted to a socket which is moved up and down by a hand wheel having attached to it a double-threaded screw working in the socket: this socket has a feather, and is moved up and down by the hand wheel upon a wiper shaft; thus the spiral incline is lowered or raised: the roller on the cross head acting upon the incline causes the wiper shaft to oscillate, and the shaft having a link connecting it to the valve spindle, shuts off the steam from the hammer. Then upon the hammer coming in contact with the work upon the anvil, be it thick and thin alternately; there is a plumper rod, as we term it, working vertically between two guides fixed to cross head or hammer: this plumper rod has a head somewhat larger in diameter than the diameter of the rod; betwixt this head and the upper guide there is a spiral spring which is sufficiently strong to support the weight of this plumper rod and to raise and retain it at its usual position: in this plumper rod there is a slot cut, into which one end of a bell crank is introduced; the other end of this bell crank, whose axis or centre is upon the cross head, plays up and down ½ inch clear of what we term the kicker bar; but so soon as the hammer strikes any substance on the anvil and comes to rest,

steam under the hammer, which instantly ra
the incline shutting it off and throwing in the
and thus the hammer rises and falls, increa
diminishing the number of strokes per
according to the fall you wish to give your h

LOGARITHMS.

Logarithms literally signify *ratios of numbers;* hence Logarithmic Tables may be various, but those in common use for the facilitating of arithmetical operations generally are of the following corresponding progressions, viz.

Arithmetical, 0, 1, 2, 3, &c., or series of logarithms.
Geometrical, 1, 10, 100, 1000, &c., or ratio of numbers.

And thus it may be perceived, that if the log. of 10 be 1, the log. of any number less than 10 must consist wholly of decimals, because increasing by a decimal ratio. Again, if the log. of 100 be 2, the log. of any intermediate number between 10 and 100 must be 1, with so many decimals annexed; and in like manner, the log. of any intermediate number between 100 and 1000 must be 2, with decimals annexed proportionally, as before.

APPLICATION AND UTILITY OF COMMON LOGARITHMIC TABLES.

The whole numbers of the series of logarithms, as 1, 2, 3, &c., are called the indices, or characteristics of the logarithm, and which must be added to the logarithm obtained by the Table, in proportion to the number of figures contained in the given sum. Thus, suppose the logarithm be required for a sum of only two figures, the index is 1; if of three figures, the index is 2; and if of four figures, the index is 3, &c., being always a number less by unity than the number of figures the given sum contains.

The index of a deci...
denotes the significant figure from the decim
and is marked with the sign thus —, to dis
it from a whole number.

Ex. The index of ·32549 is —1, because
significant figure is the first decimal.

The index of ·032549 is —2, because
significant figure is the second decimal.

The index of ·0032549 is —3, because
significant figure is the third decimal, and
any other sum.

If the given sum for which the logarit
quired contains or consists of both integers
mals, the index is determined by the inte
without having any regard to the other.

1. *To find the logarithm of any whol
under* 100.

Look for the number under N in the fir
any Logarithmic Table; then immediately o
of it is the logarithm required, with its pro
Thus, the log. of 64 is 1·806180, and the
is 1·857332.

...rithm of any numb

figure, and in a line with the three figures in the column on the left, with its proper index, is the logarithm required. Thus, the log. of 450 is 2·653213, and the log. of 7464 is 3·872972. Or, the log. of 378·5 is 2·578066, and that of ·7854 is —1·895091.

3. *To find the number indicated by a given logarithm.*

Look for the decimal part of the given logarithm in the different columns, and if it cannot be found exactly, take the next less. Then under N in the left-hand column, and in a line with the logarithm found, are three figures of the number required, and on the top of the column in which the found logarithm stands is one figure more; place the decimal point as indicated by the logarithmic index, which determines the sum, properly valued, as required.

If the logarithm cannot be found exactly in the Tables, subtract from it the next less that can be found, and divide the remainder by the tabular difference; the quotient will be the rest of the figures of the given number, which, being annexed to the tabular number already found, is the proper number required.

Ex. Required the number answering to the logarithm 3·233568.

Given logarithm ....=3·233568
Next less is the log. of 1712 ...=3·233504
Remainder 64

Tab. Diff.=253, and $\frac{64}{253}$=·25

Hence the number required=1712·25.

For practical purposes in mechanics, logarithms are seldom resorted to, unless for the raising of the powers of numbers or extraction of their roots: these

Ex. 1. Required the square or second p(
25·791.

Log. of 25·791 =1·411468
Multiplied by 2, the power required.

Logarithm 2·822936, indicated number or s
quired=665·175.

Ex. 2. What is the cube of 30·7146 ?

Logarithm =1·487345
Multiplied by 3, the power required.

Logarithm 4·462035, indicated number or
quired=28975·7.

Ex. 3. Required the square root of 365.

Log.$=\frac{2\cdot562293}{2}=1\cdot281146$, indicated number
19·105.

Ex. 4. Find the cube root of 12345.

Log.$=\frac{4\cdot091491}{3}=1\cdot363830$, indicated number
23·1116.

Table of Logarithms from 1 *to* 100.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0·000000	26	1·414973	51	1·707570	76	1·880814
2	0·301030	27	1·431364	52	1·716003	77	1·886491
3	0·477121	28	1·447158	53	1·724276	78	1·892095
4	0·602060	29	1·462398	54	1·732394	79	1·897627
5	0·698970	30	1·477121	55	1·740363	80	1·903090
6	0·778151	31	1·491362	56	1·748188	81	1·908485
7	0·845098	32	1·505150	57	1·755875	82	1·913814
8	0·903090	33	1·518514	58	1·763428	83	1·919078
9	0·954243	34	1·531479	59	1·770852	84	1·924279
10	1·000000	35	1·544068	60	1·778151	85	1·929419
11	1·041393	36	1·556303	61	1·785330	86	1·934498
12	1·079181	37	1·568202	62	1·792392	87	1·939519
13	1·113943	38	1·579784	63	1·799341	88	1·944483
14	1·146128	39	1·591065	64	1·806180	89	1·949390
15	1·176091	40	1·602060	65	1·812913	90	1·954243
16	1·204120	41	1·612784	66	1·819544	91	1·959041
17	1·230449	42	1·623249	67	1·826075	92	1·963788
18	1·255273	43	1·633468	68	1·832509	93	1·968483
19	1·278754	44	1·643453	69	1·838849	94	1·973128
20	1·301030	45	1·653213	70	1·845098	95	1·977724
21	1·322219	46	1·662758	71	1·851258	96	1·982271
22	1·342423	47	1·672098	72	1·857332	97	1·986772
23	1·361728	48	1·681241	73	1·863323	98	1·991226
24	1·380211	49	1·690196	74	1·869232	99	1·995635
25	1·397940	50	1·698970	75	1·875061	100	2·000000

Note.—For accurate Tables of Logarithms of a convenient size, see Tables of Logarithms in Mr. Weale's Rudimentary Series, being Vols. 94 and 95 of that series.

[redacted]

ender the following Tables more generally useful.

aches multiplied by ·04328, or the areas in feet multiplied
number of imperial gallons at 1 foot in depth.

feet multiplied by ·03704, the product equal the number of
th.

in inches multiplied by the length or thickness in inches, and
the weight in lbs. of cast iron.

ietre, or unit of solid measure, equal 35·31716 English cubic feet. Alsc
s of capacity, equal 61·028 English cubic inches, or about ·453 of a

Dia. in inch.	in inch.	sq. inc
1/16	·196	·003
1/8	·392	·012
3/16	·589	·027
1/4	·785	·049
5/16	·981	·076
3/8	1·178	·110
7/16	1·374	·150
1/2	1·570	·196
9/16	1·767	·248
5/8	1·963	·306
11/16	2·159	·371
3/4	2·356	·441
13/16	2·552	·518
7/8	2·748	·601
15/16	2·945	·69
1 in.	3 1/8	·78
1 1/8	3 1/2	·99
1 1/4	3 7/8	1·2
1 3/8	4 1/4	1·4
1 1/2	4 5/8	1·7
1 5/8	5 1/8	2·0
1 3/4	5 1/2	2·4
1 7/8	5 7/8	2·
2 in.	6 1/4	3·
2 1/8	6 5/8	3·
2 1/4	7	3
2 3/8	7 3/8	4

Dia. in inch.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.	Dia. in inch.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.
4 in.	1	0½	12·566	·0879	9 in.	2	4¼	63·617	·4453
4⅛	1	0⅞	13·364	·0935	9⅛	2	4⅝	65·396	·4577
4¼	1	1⅜	14·186	·0993	9¼	2	5	67·200	·4704
4⅜	1	1¾	15·033	·1052	9⅜	2	5⅜	69·029	·4832
4½	1	2⅛	15·904	·1113	9½	2	5¾	70·882	·4961
4⅝	1	2½	16·800	·1176	9⅝	2	6¼	72·759	·5093
4¾	1	2⅞	17·720	·1240	9¾	2	6⅝	74·662	·5226
4⅞	1	3¼	18·665	·1306	9⅞	2	7	76·588	·5361
5 in.	1	3⅝	19·635	·1374	10 in.	2	7⅜	78·540	·5497
5⅛	1	4⅛	20·629	·1444	10⅛	2	7¾	80·515	·5636
5¼	1	4½	21·647	·1515	10¼	2	8⅛	82·516	·5776
5⅜	1	4⅞	22·690	·1588	10⅜	2	8½	84·540	·5917
5½	1	5¼	23·758	·1663	10½	2	8⅞	86·590	·6061
5⅝	1	5⅝	24·850	·1739	10⅝	2	9⅜	88·664	·6206
5¾	1	6	25·967	·1817	10¾	2	9¾	90·762	·6353
5⅞	1	6⅜	27·108	·1897	10⅞	2	10⅛	92·855	·6499
6 in.	1	6¾	28·274	·1979	11 in.	2	10½	95·033	·6652
6⅛	1	7¼	29·464	·2062	11⅛	2	10⅞	97·205	·6804
6¼	1	7⅝	30·679	·2147	11¼	2	11¼	99·402	·6958
6⅜	1	8	31·919	·2234	11⅜	2	11¾	101·623	·7143
6½	1	8⅜	33·183	·2322	11½	3	0⅛	103·869	·7270
6⅝	1	8¾	34·471	·2412	11⅝	3	0½	106·139	·7429
6¾	1	9¼	35·784	·2504	11¾	3	0⅞	108·434	·7590
6⅞	1	9½	37·122	·2598	11⅞	3	1¼	110·753	·7752
7 in.	1	10	38·484	·2693	12 in.	3	1⅝	113·097	·7916
7⅛	1	10⅜	39·871	·2791	12⅛	3	2	115·466	·8082
7¼	1	10¾	41·282	·2889	12¼	3	2½	117·859	·8250
7⅜	1	11⅛	42·718	·2990	12⅜	3	2⅞	120·276	·8419
7½	1	11½	44·178	·3092	12½	3	3¼	122·718	·8590
7⅝	1	11⅞	45·663	·3196	12⅝	3	3⅝	125·185	·8762
7¾	2	0⅜	47·173	·3299	12¾	3	4	127·676	·8937
7⅞	2	0¾	48·707	·3409	12⅞	3	4⅜	130·192	·9113
8 in.	2	1⅛	50·265	·3518	13 in.	3	4¾	132·732	·9291
8⅛	2	1½	51·848	·3629	13⅛	3	5¼	135·297	·9470
8¼	2	1⅞	53·456	·3741	13¼	3	5⅝	137·886	·9642
8⅜	2	2¼	55·088	·3856	13⅜	3	6	140·500	·9835
8½	2	2⅝	56·745	·3972	13½	3	6⅜	143·139	1·0019
8⅝	2	3	58·426	·4089	13⅝	3	6¾	145·802	1·0206
8¾	2	3⅜	60·132	·4209	13¾	3	7⅛	148·489	1·0294
8⅞	2	3⅞	61·862	·4330	13⅞	3	7½	151·201	1·0584

14⅜	3	9⅛	162·295	[illegible]	[illegible]			
14½	3	9½	165·130	1·1569	19½	5	1¼	29
14⅝	3	9⅞	167·989	1·1749	19⅝	5	1⅝	30
14¾	3	10¼	170·873	1·1961	19¾	5	2	30
14⅞	3	10⅝	173·782	1·2164	19⅞	5	2⅜	31
15	3	11⅛	176·715	1·2370	20	5	2⅞	31
15⅛	3	11½	179·672	1·2577	20⅛	5	3¼	31
15¼	3	11⅞	182·654	1·2785	20¼	5	3⅝	32
15⅜	4	0¼	185·661	1·2996	20⅜	5	4	32
15½	4	0⅝	188·692	1·3208	20½	5	4⅜	33
15⅝	4	1	191·748	1·3422	20⅝	5	4¾	33
15¾	4	1⅜	194·828	1·3637	20¾	5	5⅛	33
15⅞	4	1⅞	197·933	1·3855	20⅞	5	5½	3
16	4	2¼	201·062	1·4074	21	5	5⅞	3
16⅛	4	2⅝	204·216	1·4295	21⅛	5	6⅜	3
16¼	4	3	207·394	1·4517	21¼	5	6¾	3
16⅜	4	3⅜	210·597	1·4741	21⅜	5	7⅛	[illegible]
16½	4	3¾	213·825	1·4967	21½	5	7½	[illegible]
16⅝	4	4¼	217·077	1·5195	21⅝	5	7⅞	[illegible]
16¾	4	4⅝	220·353	1·5424	21¾	5	8¼	[illegible]
16⅞	4	5	223·654	1·5655	21⅞	5	8¾	
17	4	5⅜	226·980	1·5888	22	5	9⅛	
17⅛	4	5¾	230·330	1·6123	22⅛	5	9½	
17¼	4	6⅛	233·705	1·6359	22¼	5	9⅞	
17⅜	4	6½	237·104	1·6597	22⅜	5	10¼	
17½	4	6⅞	240·528	1·6836	22½	5	10⅝	
[illegible]	4	7⅜	243·977	1·7078	22⅝	5	11	
				[illegible]	[illegible]	5	[illegible]	

Dia. in ft.	in.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.	Dia. in ft.	in.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.
2	0	6	3⅜	452·390	3·1418	2	10	8	10¾	907·922	6·3051
2	0¼	6	4⅛	461·864	3·2075	2	10¼	8	11½	921·323	6·3981
2	0½	6	4⅞	471·436	3·2731	2	10½	9	0⅜	934·822	6·4911
2	0¾	6	5¾	481·106	3·3410	2	10¾	9	1⅛	948·419	6·5863
2	1	6	6½	490·875	3·4081	2	11	9	1⅞	962·115	6·6815
2	1¼	6	7¼	500·741	3·4775	2	11¼	9	2¾	975·908	6·7772
2	1½	6	8⅛	510·706	3·5468	2	11½	9	3½	989·800	6·8738
2	1¾	6	8⅞	520·769	3·6101	2	11¾	9	4¼	1003·79	6·9701
2	2	6	9⅝	530·930	3·6870	3	0	9	5	1017·87	7·0688
2	2¼	6	10½	541·189	3·7583	3	0¼	9	5⅞	1032·06	7·1671
2	2½	6	11¼	551·547	3·8302	3	0½	9	6⅝	1046·35	7·2664
2	2¾	7	0	562·002	3·9042	3	0¾	9	7½	1060·73	7·3662
2	3	7	0¾	572·556	3·9761	3	1	9	8¼	1075·21	7·4661
2	3¼	7	1⅝	583·208	4·0500	3	1¼	9	9	1089·79	7·5671
2	3½	7	2⅜	593·958	4·1241	3	1½	9	9⅞	1104·46	7·6691
2	3¾	7	3⅛	604·807	4·2000	3	1¾	9	10½	1119·24	7·7791
2	4	7	3⅞	615·753	4·2760	3	2	9	11⅜	1134·12	7·8681
2	4¼	7	4¾	626·798	4·3521	3	2¼	10	0⅛	1149·09	7·9791
2	4½	7	5½	637·941	4·4302	3	2½	10	0⅞	1164·16	8·0846
2	4¾	7	6¼	649·182	4·5083	3	2¾	10	1¾	1179·32	8·1891
2	5	7	7	660·521	4·5861	3	3	10	2½	1194·59	8·2951
2	5¼	7	7⅞	671·958	4·6665	3	3¼	10	3¼	1209·95	8·4026
2	5½	7	8⅝	683·494	4·7467	3	3½	10	4	1225·42	8·5091
2	5¾	7	9½	695·128	4·8274	3	3¾	10	4⅞	1240·98	8·6171
2	6	7	10¼	706·860	4·9081	3	4	10	5⅝	1256·64	8·7269
2	6¼	7	11	718·690	4·9901	3	4¼	10	6⅜	1272·39	8·8361
2	6½	7	11¾	730·618	5·0731	3	4½	10	7¼	1288·25	8·9462
2	6¾	8	0⅝	742·644	5·1573	3	4¾	10	8	1304·20	9·0561
2	7	8	1⅜	754·769	5·2278	3	5	10	8¾	1320·25	9·1686
2	7¼	8	2⅛	766·992	5·3264	3	5¼	10	9½	1336·40	9·2112
2	7½	8	2⅞	779·313	5·4112	3	5½	10	10⅜	1352·65	9·3936
2	7¾	8	3¾	791·732	5·4982	3	5¾	10	11⅛	1369·00	9·5061
	8	8	4½	804·249	5·5850	3	6	10	11⅞	1385·44	9·6212
	8¼	8	5⅜	816·865	5·6729	3	6¼	11	0¾	1401·98	9·7364
	8½	8	6⅛	829·578	5·7601	3	6½	11	1½	1418·62	9·8518
	8¾	8	6⅞	842·390	5·8491	3	6¾	11	2¼	1435·36	9·9671
	9	8	7⅝	855·300	5·9398	3	7	11	3	1452·20	10·084
	9¼	8	8½	868·308	6·0291	3	7¼	11	3⅞	1469·14	10·202
	9½	8	9¼	881·415	6·1201	3	7½	11	4⅝	1486·17	10·320
	9¾	8	10	894·619	6·2129	3	7¾	11	5½	1503·30	10·439

[redacted]

3	9	11	9⅜	1590·43	11·044	4	7	14	4¾
3	9¼	11	10⅛	1608·15	11·167	4	7¼	14	5½
3	9½	11	10⅞	1625·97	11·291	4	7½	14	6⅜
3	9¾	11	11¾	1643·89	11·415	4	7¾	14	7⅛
3	10	12	0½	1661·90	11·534	4	8	14	7⅞
3	10¼	12	1¼	1680·02	11·666	4	8¼	14	8⅝
3	10½	12	2	1698·23	11·793	4	8½	14	9½
3	10¾	12	2⅞	1716·54	11·920	4	8¾	14	10¼
3	11	12	3⅝	1734·94	12·048	4	9	14	11
3	11¼	12	4⅜	1753·45	12·176	4	9¼	14	11⅞
3	11½	12	5¼	1772·05	12·305	4	9½	15	0⅝
3	11¾	12	6	1790·76	12·435	4	9¾	15	1⅜
4	0	12	6¾	1809·56	12·566	4	10	15	2¼
4	0¼	12	7½	1828·46	12·697	4	10¼	15	2⅞
4	0½	12	8⅜	1847·45	12·829	4	10½	15	3¾
4	0¾	12	9⅛	1866·55	12·962	4	10¾	15	4½
4	1	12	9⅞	1885·74	13·095	4	11	15	5¼
4	1¼	12	10¾	1905·03	13·229	4	11¼	15	6⅛
4	1½	12	11½	1924·42	13·364	4	11½	15	6⅞
4	1¾	13	0¼	1943·91	13·499	4	11¾	15	7¾
4	2	13	1	1963·50	13·635	5	0	15	8½
4	2¼	13	1⅞	1983·18	13·772	5	0¼	15	9¼
4	2½	13	2⅝	2002·96	13·909	5	0½	15	10
4	2¾	13	3⅜	2022·84	14·047	5	0¾	15	10¾
4	3	13	4¼	2042·82	14·186	5	1	15	11⅝
4	3¼	13	5	2062·90	14·325	5	1¼	16	0⅜
4	3½	13	5¾	2083·07	14·465	5	1½	16	1¼

Dia. in ft.	in.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.	Dia. in ft.	in.	Circum. in ft.	in.	Area in sq. inch.	Area in sq. feet.
5	4	16	9	3216·99	22·333	6	2	19	4½	4300·85	29·867
5	4¼	16	9¾	3242·17	22·515	6	2¼	19	5¼	4329·95	30·069
5	4½	16	10⅝	3267·46	22·621	6	2½	19	6	4359·16	30·271
5	4¾	16	11⅜	3292·83	22·866	6	2¾	19	6¾	4388·47	30·475
5	5	17	0⅛	3318·31	23·043	6	3	19	7⅝	4417·87	30·679
5	5¼	17	0⅞	3343·88	23·221	6	3¼	19	8⅜	4447·37	30·884
5	5½	17	1¾	3369·56	23·330	6	3½	19	9⅛	4476·97	31·090
5	5¾	17	2½	3395·33	23·578	6	3¾	19	9⅞	4506·67	31·296
5	6	17	3⅜	3421·20	23·758	6	4	19	10¾	4536·47	31·503
5	6¼	17	4⅛	3447·16	23·938	6	4¼	19	11½	4566·36	31·710
5	6½	17	4⅞	3473·23	24·119	6	4½	20	0¼	4596·35	31·919
5	6¾	17	5⅝	3499·39	24·301	6	4¾	20	1⅛	4626·44	32·114
5	7	17	6½	3525·66	24·483	6	5	20	1⅞	4656·63	32·337
5	7¼	17	7¼	3552·01	24·666	6	5¼	20	2⅝	4686·92	32·548
5	7½	17	8	3578·47	24·850	6	5½	20	3½	4717·30	32·759
5	7¾	17	8¾	3605·03	25·034	6	5¾	20	4¼	4747·79	32·970
5	8	17	9⅝	3631·68	25·220	6	6	20	5	4778·37	33·183
5	8¼	17	10⅜	3658·44	25·405	6	6¼	20	5¾	4809·05	33·396
5	8½	17	11⅛	3685·29	25·592	6	6½	20	6½	4839·83	33·619
5	8¾	17	11⅞	3712·24	25·779	6	6¾	20	7⅜	4870·70	33·824
5	9	18	0¾	3739·28	25·964	6	7	20	8⅛	4901·68	34·039
5	9¼	18	1½	3766·43	26·155	6	7¼	20	8⅞	4932·75	34·255
5	9½	18	2¼	3793·67	26·344	6	7½	20	9¾	4963·92	34·471
5	9¾	18	3⅛	3821·02	26·534	6	7¾	20	10½	4995·19	34·688
5	10	18	3⅞	3848·46	26·725	6	8	20	11¼	5026·26	34·906
5	10¼	18	4⅝	3875·99	26·916	6	8¼	21	0⅛	5058·02	35·125
5	10½	18	5½	3903·63	27·108	6	8½	21	0⅞	5089·58	35·344
5	10¾	18	6¼	3931·36	27·301	6	8¾	21	1⅝	5121·24	35·564
5	11	18	7	3959·20	27·494	6	9	21	2⅜	5153·00	35·784
5	11¼	18	7¾	3987·13	27·688	6	9¼	21	3¼	5184·86	36·006
5	11½	18	8⅝	4015·16	27·883	6	9½	21	4	5216·82	36·227
5	11¾	18	9⅜	4043·28	28·078	6	9¾	21	4¾	5248·87	36·450
6	0	18	10⅛	4071·51	28·274	6	10	21	5½	5281·02	36·674
6	0¼	18	10⅞	4099·83	28·471	6	10¼	21	6⅜	5313·27	36·897
6	0½	18	11¾	4128·25	28·668	6	10½	21	7⅛	5345·62	37·122
6	0¾	19	0½	4156·77	28·866	6	10¾	21	7⅞	5378·07	37·347
6	1	19	1¼	4185·39	29·065	6	11	21	8¾	5410·62	37·573
6	1¼	19	2⅛	4214·11	29·264	6	11¼	21	9½	5443·26	37·700
6	1½	19	2⅞	4242·92	29·466	6	11½	21	10¼	5476·00	38·027
6	1¾	19	3⅝	4271·83	29·665	6	11¾	21	11	5508·84	38·256

	2	22	6⅛	40·3388		2	31	11¾
	3	22	9¼	41·2825		3	32	2⅝
	4	23	0⅜	42·2367		4	32	5¼
	5	23	2⅛	43·2022		5	32	8⅝
	6	23	6¾	44·1787		6	32	11¾
	7	23	11	45·1656		7	33	2⅞
	8	24	1⅛	46·1638		8	33	6⅛
	9	24	4⅛	47·1730		9	33	9¼
	10	24	7¼	48·1926		10	34	0⅝
	11	24	10⅝	49·2236		11	34	3
8	0	25	1⅛	50·2656	11	0	34	6
	1	25	4⅝	51·3178		1	34	9
	2	25	7⅞	52·3816		2	35	0
	3	25	11	53·4562		3	35	4
	4	26	2⅛	54·5412		4	35	7
	5	26	5¾	55·6377		5	35	10
	6	26	8⅝	56·7451		6	36	1
	7	26	11⅛	57·8628		7	36	4
	8	27	2¾	58·9920		8	36	7
	9	27	5¾	60·1321		9	36	10
	10	27	9	61·2826		10	37	[illegible]
	11	28	0⅛	62·4445		11	37	[illegible]
9	0	28	3¼	63·6174	12	0	37	[illegible]
	1	28	6⅝	64·8006		1	37	1
	2	28	9⅛	65·9951		2	38	

ia. in & in.		Circum. in ft. and in.		Area in feet.	Dia. in ft. & in.		Circum. in ft. and in.		Area in feet.
3	0	40	10	132·7326	16	0	50	3⅛	201·0624
	1	41	1⅛	134·4391		1	50	6¼	203·1615
	2	41	4⅜	136·1574		2	50	9⅜	205·2726
	3	41	7½	137·8867		3	51	0½	207·3946
	4	41	10⅝	139·6260		4	51	3¾	209·5264
	5	42	1⅞	141·3771		5	51	6⅞	211·6703
	6	42	4⅞	143·1391		6	51	10	213·8251
	7	42	8	144·9111		7	52	1⅛	215·9896
	8	42	11⅛	146·6949		8	52	4¼	218·1662
	9	43	2¼	148·4896		9	52	7⅜	220·3537
	10	43	5½	150·2943		10	52	10½	222·5510
	11	43	8⅝	152·1109		11	53	1⅝	224·7603
4	0	43	11¾	153·9384	17	0	53	4⅞	226·9806
	1	44	2⅞	155·7758		1	53	8	229·2105
	2	44	6	157·6250		2	53	11⅛	231·4625
	3	44	9⅛	159·4852		3	54	2¼	233·7055
	4	45	0¼	161·3553		4	54	5⅜	235·9682
	5	45	3½	163·2373		5	54	8½	238·2430
	6	45	6⅝	165·1303		6	54	11⅝	240·5287
	7	45	9¾	167·0331		7	55	2⅞	242·8241
	8	46	0⅞	168·9479		8	55	6	245·1316
	9	46	4	170·8735		9	55	9⅛	247·4500
	10	46	7⅛	172·8091		10	56	0¼	249·7781
	11	46	11¼	174·7565		11	56	3½	252·1184
5	0	47	1½	176·7150	18	0	56	6½	254·4696
	1	47	4⅝	178·6832		1	56	9⅝	256·8303
	2	47	7¾	180·6634		2	57	0⅞	259·2033
	3	47	10⅞	182·6545		3	57	4	261·5872
	4	48	2⅛	184·6555		4	57	7⅛	263·9807
	5	48	5⅛	186·6684		5	57	10¼	266·3864
	6	48	8¼	188·6923		6	58	1⅜	268·8031
	7	48	11⅜	190·7260		7	58	4½	271·2293
	8	49	2⅝	192·7716		8	58	7⅝	273·6678
	9	49	5¾	194·8282		9	58	10¾	276·1171
	10	49	8⅞	196·8946		10	59	2	278·5761
	11	50	0	198·9730		11	59	5⅛	281·0472

212	100	80	176	80	[illegible]	[illegible]
211	99·4	79·5	175	79·4	63·5	139
210	98·8	79·1	174	78·8	63·1	138
209	98·3	78·6	173	78·3	62·6	137
208	97·7	78·2	172	77·7	62·2	136
207	97·2	77·7	171	77·2	61·7	135
206	96·6	77·3	170	76·6	61·3	134
205	96·1	76·8	169	76·1	60·8	133
204	95·5	76·4	168	75·5	60·4	132
203	95	76	167	75	60	131
202	94·4	75·5	166	74·4	59·5	130
201	93·8	75·1	165	73·8	59·1	129
200	93·3	74·6	164	73·3	58·6	128
199	92·7	74·2	163	72·7	58·2	127
198	92·2	73·7	162	72·2	57·7	12
197	91·6	73·3	161	71·6	57·3	12
196	91·1	72·8	160	71·1	56·8	12
195	90·5	72·4	159	70·5	56·4	12
194	90	72	158	70	56	12
193	89·4	71·5	157	69·4	55·5	12
192	88·8	71·1	156	68·8	55·1	12
191	88·3	70·6	155	68·3	54·6	11
190	87·7	70·2	154	67·7	54·2	11
189	87·2	69·7	153	67·2	53·7	11
188	86·6	69·3	152	66·6	53·3	11
187	86·1	68·8	151	66·1	52·8	11
186	85·5	68·4	150	65·5	52·4	1

	Degrees of			Degrees of			Degrees of	
Fah.	**Cent.**	**Reau.**	**Fah.**	**Cent.**	**Reau.**	**Fah.**	**Cent.**	**Reau.**
104	40	32	65	18·3	14·6	26	— 3·3	— 2·6
103	39·4	31·5	64	17·7	14·2	25	— 3·8	— 3·1
102	38·8	31·1	63	17·2	13·7	24	— 4·4	— 3·5
101	38·3	30·6	62	16·6	13·3	23	— 5	— 4
100	37·7	30·2	61	16·1	12·8	22	— 5·5	— 4·4
99	37·2	29·7	60	15·5	12·4	21	— 6·1	— 4·8
98	36·6	29·3	59	15	12	20	— 6·6	— 5·3
97	36·1	28·8	58	14·4	11·5	19	— 7·2	— 5·7
96	35·5	28·4	57	13·8	11·1	18	— 7·7	— 6·2
95	35	28	56	13·3	10·6	17	— 8·3	— 6·6
94	34·4	27·5	55	12·7	10·2	16	— 8·8	— 7·1
93	33·8	27·1	54	12·2	9·7	15	— 9·4	— 7·5
92	33·3	26·6	53	11·6	9·3	14	—10	— 8
91	32·7	26·2	52	11·1	8·8	13	—10·5	— 8·4
90	32·2	25·7	51	10·5	8·4	12	—11·1	— 8·8
89	31·6	25·3	50	10	8	11	—11·6	— 9·3
88	31·1	24·8	49	9·4	7·5	10	—12·2	— 9·7
87	30·5	24·4	48	8·8	7·1	9	—12·7	—10·2
86	30	24	47	8·3	6·6	8	—13·3	—10·6
85	29·4	23·5	46	7·7	6·2	7	—13·8	—11·1
84	28·8	23·1	45	7·2	5·7	6	—14·4	—11·5
83	28·3	22·6	44	6·6	5·3	5	—15	—12
82	27·7	22·2	43	6·1	4·8	4	—15·5	—12·4
81	27·2	21·7	42	5·5	4·4	3	—16·1	—12·8
80	26·6	21·3	41	5	4	2	—16·6	—13·3
79	26·1	20·8	40	4·4	3·5	1	—17·2	—13·7
78	25·5	20·4	39	3·8	3·1	zero.	—17·7	—14·2
77	25	20	38	3·3	2·6	— 1	—18·3	—14·6
76	24·4	19·5	37	2·7	2·2	— 2	—18·8	—15·1
75	23·8	19·1	36	2·2	1·7	— 3	—19·4	—15·5
74	23·3	18·6	35	1·6	1·3	— 4	—20	—16
73	22·7	18·2	34	1·1	0·8	— 5	—20·5	—16·4
72	22·2	17·7	33	0·5	0·4	— 6	—21·1	—16·8
71	21·6	17·3	32	zero.	zero.	— 7	—21·6	—17·3
70	21·1	16·8	31	—0·5	—0·4	— 8	—22·2	—17·7
69	20·5	16·4	30	—1·1	—0·8	— 9	—22·7	—18·2
68	20	16	29	—1·6	—1·3	—10	—23·3	—18·6
67	19·4	15·5	28	—2·2	—1·7	—11	—23·8	—19·1
66	18·8	15·1	27	—2·7	—2·2	—12	—24·4	—19·5

-15	[illegible]	[illegible]					
-16	—26·6	—21·3	—24	—31·1	—24·8	[illegible]	[illegible]
-17	—27·2	—21·7	—25	—31·6	—25·3	—33	—3
-18	—27·7	—22·2	—26	—32·2	—25·7	—34	—3
-19	—28·3	—22·6	—27	—32·7	—26·2	—35	—3
-20	—28·8	—23·1	—28	—33·3	—26·6		

Relative Indications of Temperature by Fah Centigrade, and Reaumur's Thermometer tically tabulated.

Degrees of Fah.	Cent.	Reau.	METALS, ETC.
2786	1530	1224	Cast Iron melts.
2500	1371	1097	Cast Steel ,,
2016	1102	882	Gold ,,
1996	1091	873	Copper, Cast ,,
1900	1038	830	Gun Metal ,,
1873	1023	818	Silver ,,
1869	1020	816	Brass ,,
810	432	345	Antimony ,,
700	371	297	Zinc ,,
594	312	250	Lead ,,
476	247	197	Bismuth ,,
442	228	182	Tin ,,
[illegible]	[illegible]	86	Sulphur ,,

Degrees of Fah.	Degrees of Cent.	Degrees of Reau.	
			ALLOYS.
210	98·8	79·1	Bismuth 8, tin 3, lead 5, melts.
138	58·8	47·1	Bismuth 15, tin 4, lead 8, and cadmium 3, „
			LIQUIDS.
662	350	280	Mercury boils.
600	315·5	252·4	Linseed oil „
590	310	248	Sulphuric acid „
560	293	235	Oil, turpentine „
98	36·6	29·3	Ether and water in a vacuum „
212	100	80	Fresh water boils, barometer 30 inches at sea level.
213·2	100·6	80·5	Common sea-water containing $\frac{1}{33}$ salt, boils under atmospheric pressure.
214·4	101·3	81	Sea-water containing $\frac{2}{33}$ boils.
215·5	102	81·6	„ „ $\frac{3}{33}$ „
216·7	102·6	82	„ „ $\frac{4}{33}$ „
217·9	103·2	82·6	„ „ $\frac{5}{33}$ „
219·1	104	83·2	„ „ $\frac{6}{33}$ „
220·3	104·5	83·6	„ „ $\frac{7}{33}$ „
			NOTE.—Relative to steam-boilers at sea, as a general rule no deposit of salt takes place up to 216·7 degrees of atmospheric boiling.
			FREEZING.
32	0	0	Freezing-point of Fah., and zero of Cent. and Reau.
28	— 2·2	— 1·7	Vinegar freezes.
27½	— 2·5	— 2	Sea-water „
20	— 6·6	— 5·3	Strong Wines „
14	—10	— 8	Turpentine „
1	—17·2	—13·7	Sulphuric acid „
0	—17·7	—14·2	Zero of Fahrenheit

1. Subtract ·002 from 100.

$$\begin{array}{r} 100 \\ \cdot 002 \\ \hline 99\cdot 998 \end{array}$$ **Answer.**

2. Find the value of 24·004—·987516.

$$\begin{array}{r} 24\cdot 004 \\ \cdot 987516 \\ \hline 23\cdot 016484 \end{array}$$ **Answer.**

3. Multiply ·0001 by ·001. As there always be as many decimals in the prod there are in the factors, the product here m ·0000001.

4. Multiply ·03 by 2, by ·001 and by 6.

·03 × 2 × ·001 × 6 = ·00036, the product consi fiv decimal places, because those in the factors make number.

Express as decimals,

$$\frac{7}{10} = \cdot 7, \frac{3}{100} = \cdot 03, \frac{37}{100000} = \cdot 00037.$$

... of iron is in length 8 feet, a

6. What weight on the end of a lever 8 feet in length, will exert a force equal to 100 lbs. on the other end, 6 inches being the distance of the fulcrum from the 100 lbs?

The arm of the power is 96 in. — 6 in. = 90 in. therefore $100 \times 6 \div 90 = 6{\cdot}667$ lbs. the weight required.

7. What are the solid contents and superficial surface of a cylindrical boiler with spherical ends, the boiler being 4 feet in diameter and the cylindrical part 10 feet in length?

$4 \times 4 \times {\cdot}7854 \times 10 = 125{\cdot}664$ contents of cylindrical part.

$4 \times 4 \times 4 \times {\cdot}5236 = 33{\cdot}5104 + 125{\cdot}664 = 159{\cdot}1744$ total amount of cubic feet.

then, $4 \times 3{\cdot}1416 \times 10 = 125{\cdot}664$ surface of cylinder.

$4 \times 3{\cdot}1416 \times 4 = 50{\cdot}2656 + 125{\cdot}664 = 175{\cdot}9296$ total surface in square feet.

8. What quantity of coals will a bunker contain that is 16 feet long, 6·5 feet wide, and 18 feet in height, allowing 45 cubic feet capacity per ton?

$$16 \times 6{\cdot}5 \times 18 = 1872 \div 45 = 41{\cdot}6 \text{ tons.}$$

9. Required the necessary weight to be attached on the end of a lever for an overflow valve of 5 inches diameter, the pressure of steam in the boiler being 10 lbs. per square inch, the length of the lever 42 inches, and the fulcrum 6 inches from the centre of the valve.

$$5^2 \times {\cdot}7854 \times 10 \times 6 = 1178{\cdot}1000 \div 42 = 28{\cdot}05 \text{ lbs.}$$

10. The diameter of the screw shaft of a 100 horse-power engine is 6 inches, what should be the diameter when the power is 400 horses?

$$6 \times 6 = 36 \times 4, \text{ and } \sqrt{144} = 12 \text{ inches diameter.}$$

10 cwt. 0 qrs. ...
of copper.
and 1887 lbs. $\times$ 11 $\div$ 111 = 187 lbs. of tin.

12. The consumption of coal is 60 cwt hour, and the rate of the ship 10 knots full what will be the consumption at 8 knots, an distance will 400 tons of coals carry a ve circumstanced?

$10^3 = 1000$ and $8^3 = 512$. $512 \times 60 \div 1000 = 30$
per hour at 8 knots.
Then if 30·72 gives 8 knots, what will 400×20
Ans. 8000 cwts.
Then $8000 \times 8 \div 30{\cdot}72 = 2083{\cdot}3$ knots the distan

13. A safety valve is 6 inches diameter weight must be placed upon it to equal 12 l square inch?

$$6^2 \times {\cdot}7854 \times 12 = 339{\cdot}2928 \text{ lbs.}$$

14. The pitch of a screw propeller is 1 the number of revolutions 80 per minute; fi rate of the screw in knots per hour, supposi knot or nautical mile equal 6080 Englisl feet.

16. What should be the diameter of the piston of an indicator, the area of which is one fourth of a square inch?

$$\frac{\cdot 25000000}{\cdot 7854} = \sqrt{\cdot 3183} = \cdot 561 \text{ of an inch.}$$

17. A piece of boiler-plate (iron) is 7 feet long, 6 feet broad, and $\frac{5}{8}$ inch in thickness, how many cubic feet does it contain, and what is its weight at 25 lbs. per square foot?

$84 \times 72 \times \cdot 625 = 3780 \cdot 000 \div 1728 = 2 \cdot 187$ cubic feet.
or, $7 \times 6 \times \cdot 052 = 2 \cdot 184$ cubic feet.
$7 \times 6 \times 25 = 1050 \div 112 = 9$ cwts. 1 qr. 14 lbs.

18. What weight on the end of a lever 12 feet in length will equipoise 2 tons on the other end, the fulcrum being distant 6 inches from the weight to be equipoised, and the weight of the lever not taken into account?

$$4480 \times 6 = 26880 \div 138 = 194 \cdot 7 \text{ lbs.}$$

19. A boiler has 1800 tubes, $2\frac{1}{4}$ inches diameter and 6 feet 6 inches long, what is the total amount of heating surface, and what the horse power at 15 square feet of heating surface per horse power; also, what is the amount of smoke draught through the boiler by tubes, the metal of the tubes being $\frac{1}{8}$ of an inch in thickness.

$$2 \cdot 5 \times 3 \cdot 1416 \times 78 \times 1800 = \frac{1102701 \cdot 6}{144} \times \frac{7657 \cdot 65}{15} = 510$$

horses power.

and $2 \cdot 25^2 \times \cdot 7854 \times 1800 = 7056 \cdot 8 \div 144 = 49$ sq. feet.

Thickness of plates in part of an inch.	Multipliers.	Diameters of Rivets.	Lengths o rivets fro heads.	Distance rivets fro centre t centre.	Breadth lap for sin joints.
$\frac{3}{16}$	·19	·38	·88	1·25	1·25
$\frac{1}{4}$	·25	·5	1·13	1·5 6	1·5 6
$\frac{5}{16}$	·31	·63	1·38	1·63	1·88
$\frac{3}{8}$	·38	·75 2	1·63 4·5	1·75 5	2 5·
$\frac{1}{2}$	·5	·81	2·25	2	2·25
$\frac{5}{8}$	·63	·94 1·5	2·75	2·5 4	2·75 4·
$\frac{3}{4}$	·75	1·13	3·25	3	3·25

The numbers on the right, in the several column first two, namely, the numbers 2, 1·5, 4·5, 6, 5, 4, 4·5, are used as multipliers, as in the following ex

Let the thickness of plate equal $\frac{3}{8}$ or ·375

·375 $\times 2 = ·75$ or $\frac{3}{4}$ the diameter of rivets.
$\times 4·5 = 1·688$ or $1\frac{3}{4}$ length of rivets.
$\times 5 = 1·875$ or $1\frac{7}{8}$ distance from centre to rivets.
$\times 5·5 = 2·063$ or 2 inches breadth of lap rivets.
$\times 5·5 = 2·063 + \frac{2}{3}$rds or $1·375 = 3·448$ or

Conversion of cwts., qrs., and lbs. into lbs.

We terminate this work with the following compendious method of converting cwts., qrs., and lbs. into lbs.

RULE.—If there are cwts. only, repeat the number under itself. Below the first figure on the right put a 0, and then the figures of the same number, thus pushing those figures one place to the left. Again, commencing with two 0's, repeat the number a third time, the figures being one more place to the left, and then add up. If there be also qrs. and lbs. write the equivalent to them in lbs. under the whole before adding up, thus :—

234 cwt.	234 cwt. 3 qrs. 25 lbs.
234	234
2340	2340
23400	23400
———	109 = 3 qrs. 25 lbs.
26208 lbs.	———
	26317 lbs.

Should there be tons as well, add 20 times the number of tons to the cwts. and then proceed with the result as above.

⁂ *The foregoing method is selected out of a great variety of similar short processes, from a work entitled, "Intuitive Calculations," by Daniel O'Gorman. 23rd Edition.*

NOTE (A), *Page* 79.

THE circumference of a circle of 1 inch in diameter is 3·1416 inches. In the calculation at p. 79, the decimal part of this latter number, namely ·1416, is converted into *eighths* by multiplying it by 8, the product being 1·1328 eighths. The integral portion of these eighths, namely 1, is alone retained, and the decimals rejected, as of no practical moment. But the several successive eighths may be deduced, one after another, from the first result, more readily by continually adding the number 3·1416, thus :

Diameter.		Circumference.		
1 in.	3 in.	and	1·1328	eighths.
			3·1416	
$1\frac{1}{8}$	3	,,	4·2744	,,
			3·1416	
$1\frac{1}{4}$	3	,,	7·4160	,,
			3·1416	
$1\frac{3}{8}$	4	,,	2·5576	,,
			3·1416	
$1\frac{1}{2}$	4	,,	5·6992	,,
			3·1416	

1¼	 5	,,	7·1240	,,
			3·1416	
2	 6	,,	2·2656	,,

nd so on. The integers of the several results are alone retain
bulated. Of course the results against the diameters 1¼, 1⅝, 2,
eighths, 2 eighths, 2 eighths, are tabulated ¼, ¼, ¼. It is proper
hat any individual number in the Table may be found independe
he other numbers by multiplying 3·1416 by the diameter. Thus (
aking the diameter at 2 ft. 10¾ in., and multiplying by the fe
nches separately, we have

$$
\begin{array}{lll}
\quad 3{\cdot}1416 & \tfrac{1}{4} \text{ of } 3{\cdot}1416 = & {\cdot}7854 \\
\quad\quad 2 & \quad\quad 10 & \quad 3 \\
\hline
\text{For 2 ft.} = 6.2832 \text{ ft.} & \quad 31{\cdot}416 & 2.3562 = \text{three-f} \\
\text{For } 10\tfrac{3}{4} \text{ in.} = 2{\cdot}814 & \quad 2{\cdot}356 & \\
\quad 9{\cdot}097 \text{ ft.} & 12)33{\cdot}772 \text{ in.} & \\
\quad\quad 12 & & \\
 & \quad 2{\cdot}814 \text{ ft., for } 10\tfrac{3}{4} \text{ in.} & \\
\quad 1{\cdot}164 \text{ in.} & & \\
\quad\quad 8 & & \\
\end{array}
$$

1·312 eighths. Hence 9 ft. 1¼ in. = circumferen

The practical man may readily infer the value of the Table fr
calculation.

NOTE (B), *Page* 107.

The successive numbers in the Table may be obtained i
similar to that exhibited in the preceding Note; thus:

Diameter.		Circumference.
3 ft. 0 in.	....	9 ft. 9 in., and 4·1856 eighths.
		2·9312

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